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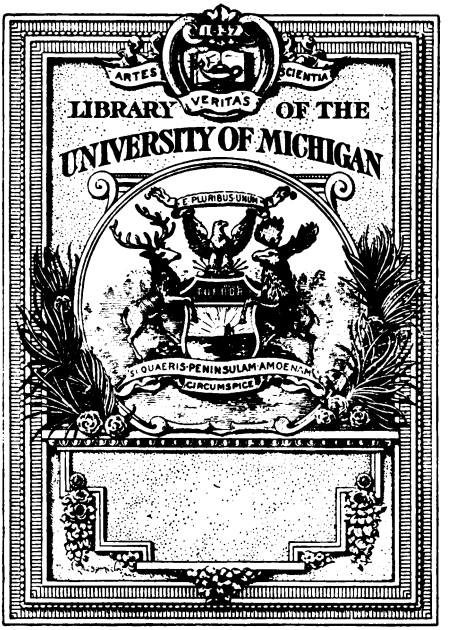

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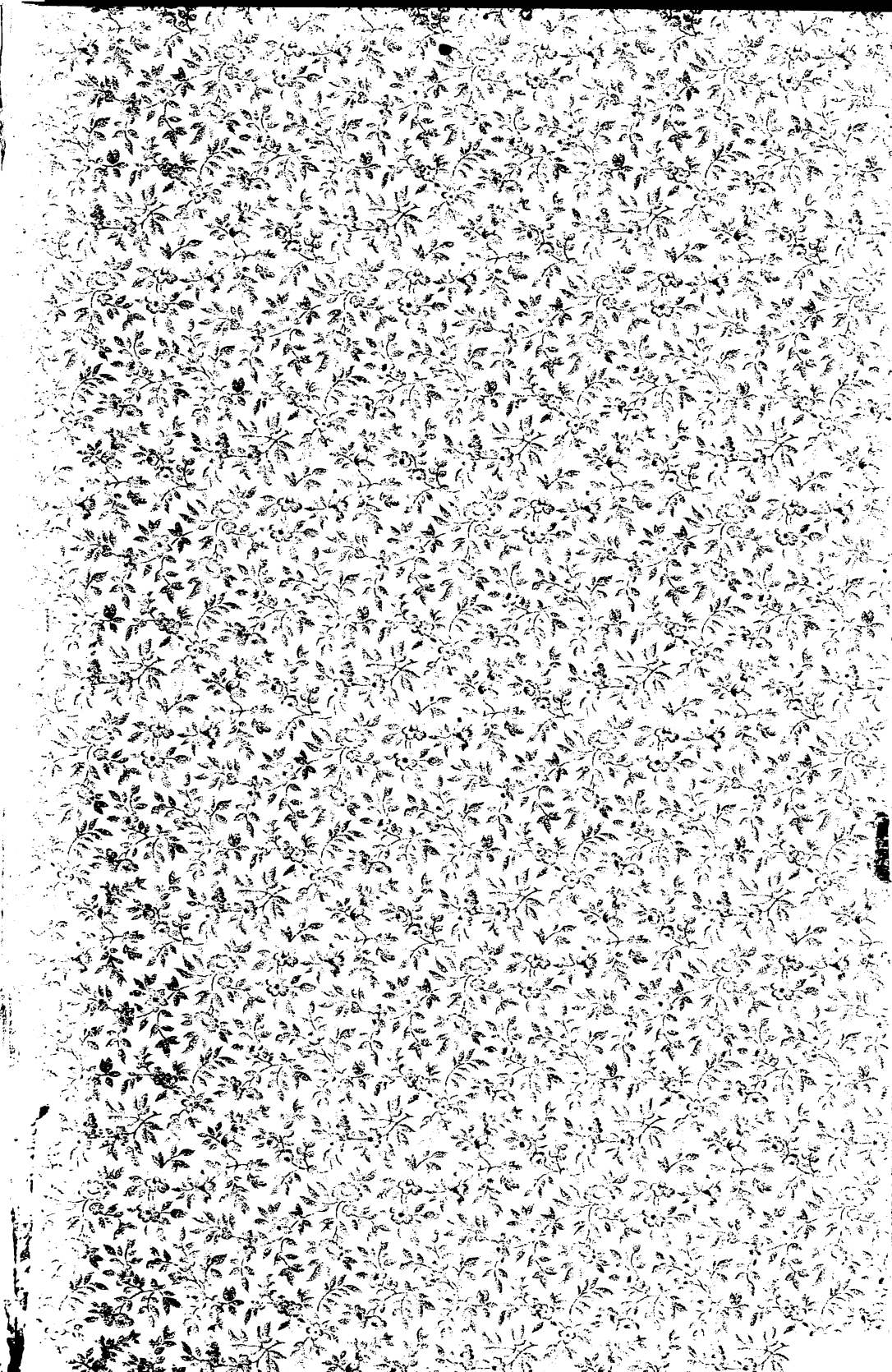

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THE FINANCE COMMISSION

OF THE

CITY OF BOSTON

VOLUME IV.

REPORT OF

SAMUEL WHINERY, CONSULTING CIVIL ENGINEER,
UPON THE STREET DEPARTMENT.

CITY OF BOSTON
PRINTING DEPARTMENT
1909

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INTRODUCTORY.

To the Finance Commission of Boston,
Boston, Mass.:

Gentlemen,— About a dozen separate reports dealing with matters connected with the work of the Street Department of the City of Boston have been made to your honorable body by me during the last year.

In compliance with your request I have undertaken to prepare these for publication. In editing them for that purpose I have followed your suggestion to condense the matter in the original reports, omitting much of the detail which seemed appropriate and useful in these original reports. The purpose has been to retain whatever may be worth permanent preservation for future reference, while at the same time supplying a succinct record of the character and scope of the work undertaken and carried out by the Commission in the Street Department.

It has not been attempted to retain the identity of the original reports nor the sequence in which these reports were submitted, but rather to arrange the matter subjectively and in appropriate order.

The following is a chronological list of the reports submitted to you:

Feb. 17, 1908.	Report on City Stone Crushers, and Cost of Crushing Stone.
Feb. 27, 1908.	Supplemental Report on Stone Crushing.
Mar. 20, 1908.	Report on Prices of Pavement in Boston.
Apr. 10, 1908.	Report on Columbus Avenue Paving Improvement.
May 1, 1908.	Report on Accounting for Supplies and Labor.
June 1, 1908.	Report on General Street Construction and Repair Work in Boston.
July 1, 1908.	Report on Proposed Reorganization of the Paving Division, Street Department.
July 5, 1908.	Report on Inquiry into Methods of Doing Street Work.
July 27, 1908.	Report on Sundry Matters Relating to Street Pavement in Boston.

Sept. 25, 1908. Sidewalks in Boston.
Oct. 19, 1908. Notes Relating to Constructing Certain Streets in the Fenway District.
Nov. 18, 1908. Report on Street Cleaning in Boston.

In addition to these there were a number of minor communications relating to the various subjects reported upon.

It is appropriate here to acknowledge the courtesy of Messrs. Metcalf & Eddy, consulting engineers, in placing at my disposal the facilities of their office, and particularly for detailing a member of their staff, Mr. Richard K. Hale, to act as my assistant in Boston, and supplying such other assistants as were needed in the work.

I am greatly indebted to Mr. Hale for his valuable and loyal assistance, and wish to express my appreciation of his ability, zeal and persistence in a work that was sometimes not altogether pleasant and often discouraging.

I wish also to express my appreciation of the courtesy and consideration I have received at the hands of your Commission during my engagement on the work.

CHAPTER I.

THE CITY STONE-CRUSHING PLANTS AND THE COST OF CRUSHING STONE.

Neither the exact time when the City of Boston first engaged in the business of producing crushed stone, nor the reasons which induced the city to enter into the business, are known. There is evidence that as early as 1871 the city was operating at least one crusher.

It is difficult to make a satisfactory investigation of the city's stone-crushing business or to determine accurately the cost of producing crushed stone from the city plants, either for any given year or for any period of years past. The amount of capital invested in the business by the city at the present or at any time in the past cannot be accurately determined. The city's accounts have not been so kept as to make it possible to reconstruct an accurate statement. Nor can the charges to capital account and those to maintenance and repair be now satisfactorily separated. The plants were frequently moved from one location to another, and no complete inventory of the property thus moved, or statement of its value, was entered upon the accounts. Only the charges for new plant and supplies and for the expenses incurred in moving and setting up the new plant were recorded. It is, therefore, impossible to find from the city books what was the first cost of the plant. This is true of all the present crushing plants except two, which were built new, outright, and even here there is more or less uncertainty as to the exact cost.

As interest and depreciation are important elements in determining the cost of any industrial product it is necessary to have at least an approximate knowledge of the cost or value of the plant employed. When it was found that this information could not be obtained from the city records it was

thought important to have an inventory taken of the present stone-crushing plants of the city. Mr. F. B. Cole, who is associated with Mr. Charles T. Main, mill engineer and architect, was employed to prepare such an inventory. He was asked to visit and carefully examine each crusher plant now operated by the city, to make a complete inventory of all city property at each, and to determine:

First. Its present value.

Second. Its value at the time the plant was erected.

In placing present values upon the plant he was asked to consider it on the basis of a going business; that is, the value of the plant was considered that which a person might afford to pay for it with the intention of continuing it in operation on the same site and under the same conditions as it is now operated by the city. This value is obviously different from and higher than the market value.

The cost of each plant when erected was more difficult to arrive at. In most cases much of the machinery and fixtures had been in use at other plants for several years previous to its erection at the present site. Mr. Cole endeavored to arrive at a fair and reasonable valuation of this "second-hand" plant, as well as at the cost of the new machinery used, the cost of erecting the machinery and the cost of the buildings. The estimated cost thus arrived at was often higher than the total charges on the city books, for the reasons already stated, but in the cases of the two plants that were built new, and of some others, his estimated cost was much below that shown by the city books. In some cases the excess cost shown by the books is so great as to excite comment, and the facts will be noted in describing the individual plants. Too much stress should not, however, be attached to these differences, as it is manifestly impossible in the absence of records, years after a plant has been built, to determine with any accuracy what was its actual first cost. Where the city records show the cost of the plants to have been greater than Mr. Cole's estimated first cost, the former has been used in computing interest and depreciation.

Table No. 1 gives an abstract of Mr. Cole's inventory valuation of each plant, and its cost as shown in the city books.

Table No. 1.— Valuation of Crushing Plants in City of Boston.

NAME OF PLANT.	Cost as Shown by City Records.	MR. COLE'S VALUATION.	
		Cost at Time of Erection.	Present Value.
Bleiler	$22,435	$14,950	$6,700
Centre street	7,976*	13,572	5,747
Chestnut Hill avenue	3,623*	16,657	6,681
Codman street	25,168*	22,350	15,633
Columbia road	35,125	30,968	13,208
Dimock street	2,912*	9,522	2,772
Grove street	4,839*	7,140	7,140
Rosseter street	19,263*	17,562	9,079
Totals	$121,341	$132,721	$66,960

The incomplete and indefinite method of keeping the city's accounts makes it also difficult to obtain accurate data relating to the cost of operating the crushing plants. The fault seems to be in the system of original cost keeping used and the vagueness of the original data rather than in any remissness on the part of the city's accounting force. The accounts are not found to be in sufficient detail, partly at least, because the information sent to the accounting department was not properly itemized and subdivided.

This is particularly true of the labor charges. It is very difficult and apparently sometimes impossible to trace back any given labor charge to its origin and to determine exactly upon what particular work the labor was expended. The original time keeping is generally to blame for this. It will be noted later that in a number of instances the labor charges for the operation of a crusher are apparently out of all proportion to the work turned out. But it is not possible without far greater labor, time and expense than we have felt justified in incurring, to determine exactly how these abnormal charges have come about. On their face, they look suspicious, and suggest fraud, but it is hardly warrant-

* This cost is incomplete; it does not include cost of material used from other plants

able to assume that they are fraudulent in the absence of definite proof.

It has not been attempted to review the city's stone-crushing business except over a comparatively short period of years. Attention has been given in a general way to the period of ten years, 1897 to 1907, inclusive, but special attention has been confined to the last three years, 1905, 1906 and 1907.

When the examination was first begun, with special reference to these three years, it was thought best to base it upon the *calendar* instead of the *fiscal* year. Later when some examination was thought best, going back over ten years, it was found that it would be much more convenient to refer to the fiscal years. Consequently, the figures relating to the more careful study for the three last years often do not agree with the records for the fiscal years, which end a month later than the calendar years. While the difference is not usually important it would have been better to adhere to the fiscal year in all cases. but it was not thought worth while to revise the accounts already gotten together. Where practicable, the figures for both the fiscal and the calendar year are given.

The city's crushing plants are controlled and operated by the Department of Streets, and the product is largely used for the construction of new and the repair of old street pavements and sidewalks, though a considerable quantity is used for other purposes.

The crushers are located on lots containing a "ledge" or quarry of rock. These lots are usually leased by the city, the rental being paid in the form of a royalty on the stone taken out. Three of the lots now occupied by crushers are, however, owned by the city. The crushers are, in all cases except one (not in use previous to 1907), operated by the city, but the rock is usually quarried and delivered to the crushers by contract at a stated price per ton. During the winter months, however, rock is often quarried and the crushing plant operated directly by the city's forces, with the object, apparently, of furnishing employment to city employees when other street work cannot be carried on.

This matter will be further considered later in this report.

Wagon scales are provided at each plant by the city and a sworn city weigher is in charge of each. All the material excavated is weighed, as well as all the crushed stone sent out from the plant.

The weigher makes a daily and a summarized monthly report to the Street Department of the rock delivered to the crusher, the stripping wasted, the crushed stone sent out from the crusher, and the destination of the latter. Blank forms are provided for the purpose. All records are also entered upon a record book kept at the scale house or the department yard. The system of original record and accounting thus provided is excellent, and the books and records at all the crusher plants were found in fair condition. The reports sent from the crusher to the Street Department form the basis of the accounts kept with the crushers in the city ledgers. Memoranda are also kept at the crushers of the number of men employed each day, both by the contractor and by the city, but these, while they may be accurate as to the time of the men employed by the city, are not very definite or complete as to the character of the labor performed or the accounts in detail to which the labor should be charged.

Occasional discrepancies are found between the crusher records and the city books, due mostly to clerical errors, but these discrepancies are generally small and comparatively unimportant. The scales appear to be occasionally tested and they are generally in good repair.

The record books at the plant are kept, for the most part, by men with little or no clerical experience, but the work is of the simplest nature. The trouble seems to be caused by failure to return records rather than by error, as one instance was noted where a large amount of stone was taken by a private contractor in 1906 and no record of it returned to the City Hall until recently.

The records kept at the crusher plant are continuous from year to year; that is, to the balance of stone on hand at the end of one year, as shown by the record, is added the quantity of crushed stone produced during the next year, from

this is subtracted the quantity of crushed stone sent out from the crusher during the year, and the balance is assumed to be the quantity on hand at the end of the year. During the year 1906 the quantity of crushed stone on hand at the crushers was measured up by the City Engineer's department, and the result compared with the balances shown to be on hand by the crusher records. In nearly every case the quantity found by such measurement to be actually on hand was smaller than that called for by the records, the difference in some cases being quite large. These discrepancies are not regarded, however, as being of much significance. In many cases it was difficult to obtain accurate measurements, owing to the irregular surface of the ground upon which the stone was stored, and it is inevitable that during a long period of storage more or less of the finer material will be carried away by wind and water or be lost in other natural and unavoidable ways. In the case of some of the larger discrepancies they may indicate inaccuracies or irregularities in the work of the weigher, or, possibly, that stone had been taken from the piles of which no record had been made.

Eight crushing plants are now owned by the city (though one of these was not operated until 1907), which will be designated in this report as follows:

The Bleiler ledge crusher.
The Centre street crusher.
The Chestnut Hill avenue crusher.
The Codman street crusher.
The Columbia road crusher.
The Dimock street crusher.
The Grove street crusher.
The Rosseter street crusher.

Brief descriptions of each of these plants, accounts of their operation and remarks and deductions relating to their management will be given.

BLEILER LEDGE CRUSHER.

Description.

This crusher is located on Heath street, near Day street, Roxbury.

It is inferred that there must have been a crusher on this lot as early as 1891, as a contract for rock at 18 cents per ton, dated November 15, 1891, was found, but no records relating to such a crusher were found.

A crusher plant was built on this location in 1896, at a cost (as shown by the city records) of $5,946.88. A part of the machinery was brought from Kenney's ledge, but apparently was not charged to the cost of this plant. After various moves and changes, no satisfactory record of which could be found at the City Hall, this plant was moved back to Kenney's ledge in 1900, at a cost of $10,779.60.

The present plant was built in 1903–04, and was practically new at that time, no old material from other plants being used in its construction.

The ledge and the lot upon which the present plant is erected was leased from Frederick Bleiler June 8, 1903. Upon its expiration it was extended to February 1, 1906. No further lease seems to have been made since that date, so that the city has had no legal title to the land for nearly two years, although its crusher is still upon the lot. The terms of the lease were that the city should pay Bleiler 18 cents per ton for all the stone taken out.

Previous leases were held by the city on this property as follows:

Lease dated November 15, 1891, price	18 cents per ton.
Lease dated March 30, 1896, price	20 cents per ton.
Lease dated April 1, 1898, price	20 cents per ton.

This ledge is now practically exhausted and the crusher is only run to crush old curbing and paving blocks.

According to the city accounts the cost of this plant erected was	$22,435 00
But Mr. Cole's inventory and estimate gives the reasonable first cost of the plant complete as	14,950 00
A difference of	$7,485 00

Mr. Cole's estimate of the present value of the plant is $6,700. The average depreciation, based on Mr. Cole's first cost, and calling the age of the plant four years, is 14 per cent per year. Considering that the ledge is practically exhausted, and that the plant must be torn down and rebuilt before it will be of further use to the city, this estimated depreciation is conservative. Forty-two per cent of the appraised first cost was for buildings which will have practically no value when the plant shall be moved. Based upon the city's record of cost, the depreciation is at the rate of 17½ per cent per year.

The rock was quarried and delivered to the crusher by contract, under a contract made with P. F. Donovan dated April 7, 1904. This contract was discontinued January 19, 1906.

Under this contract the city supplied the contractor, free of cost, the steam to operate the power drills, and the city paid him 70 cents per ton of 2,000 pounds for every ton of material taken out, whether rock or stripping.

The capacity of the plant is said to be 100 tons of crushed stone per day.

Operation.

The output of the crusher and the cost of the crushed stone produced for the fiscal years 1904 to 1906, inclusive, are given in Table No. 2. The cost of crushing, as shown by the city records, as well as that cost with interest and depreciation added are given, reckoning interest at 4 per cent on $22,435 and depreciation at 17½ per cent.

Table No. 2.

Year.	Output, Tons of Crushed Stone.	Cost from City Records.		Interest, 4 Per Cent. Depreciation, 17½ Per Cent.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1904	24,658	$37,274	$1 512	$4,823	$0 195	$1 707
1905	33,935	43,807	1 291	4,823	142	1 433
1906	1,950	12,160	6 236	4,823	2 473	8 709
Totals	60,543	$93,241	—	—	—	—
Averages	20,181	31,080	$1 539	$4,823	$0 239	$1 778

The details of cost per ton for the calendar years 1905 and 1906 differ somewhat from those given in the previous table for the fiscal years, and together with the figures for 1907 are as follows:

Table No. 3.

ITEMS OF COST PER TON.	1905.	1906.	1907.
Quantity of output for calendar years (tons)	33,579	2,090	103.6
Interest and depreciation ($4,823)	$0 144	$2 309	$46 54
Rental (royalty paid)	192	116	35
Quarrying	987	213	—
Labor	178	3 495	36 34
Teams *	—	198	07
Coal, oil and light	030	122	1 21
Repairs	024	084	2 63
Sundry items	—	103	60
	$1 555	$6 640	$87 74

The excessive unit cost of the work done in 1906 and 1907 is partly due to the small output these years. This is true particularly of the charge for interest and depreciation. But no explanation is obtainable from the records of the excessive charges for labor and teams. The books show that the total charges for some of the items were as follows:

	1906.	1907.
Pay roll charges	$7,308 30†	$3,780 73
For teams	414 50	7 50
Coal, oil and light	255 79	125 00

The actual expenditures charged to this crusher in the fiscal year 1907 were as follows:

Rental (royalty)	$36 27
Quarrying	—
Labor (city)	3,768 17
Teams	7 50
Coal, oil and light	125 00
Repairs	273 20
Sundry items	62 54
Total	$4,272 68

* The charge for teams in the operation of this and other crushers is for hauling the stone from the storage bins, after these become full, and storing it in piles on the lots.

† Does not include holidays paid for.

The city paid out this large sum of money for the production of 104 tons of crushed stone.

It appears from the records that the plant was operated for thirty-five days during the calendar year 1906 and for only three days during the calendar year 1907; if so the average quantity crushed per day was less than 60 tons in 1906 and about 35 tons in 1907.

It is obvious that no such expenses as those given above could have been honestly incurred in the time or for the very small quantity of stone crushed during these two years. If the labor, for instance, was actually performed and paid for by the city it must have been wrongly charged against this crusher, either erroneously or purposely. As these excessive charges are found in the accounts of several of the crushers for the years 1906 and 1907 they will be collectively discussed later in this report.

The contract price for quarrying was 70 cents per ton, both rock and waste stripping being paid for. In 1905 only 71 per cent and in 1906 only 73 per cent of the total excavation was rock. This accounts for the high cost of the quarried rock.

CENTRE STREET CRUSHER.

This crusher is located on Centre street, near Allandale road, West Roxbury.

A crusher had been operated in this neighborhood before the present plant was built, but no particulars of its history have been obtained.

The present plant was erected in 1896, and has been operated since that date. Some of the machinery was moved from the Commonwealth avenue ledge.

Description.

The first lease was made from J. M. Minton, August 1, 1896, another was entered into with T. Minton, January 2, 1899. On April 20, 1900, the same property was again leased from Joseph H. Rowe, and on May 10, 1902, another lease was taken from T. Minton, which, upon expiration, was

extended until February 1, 1906. This lease was again (September 4, 1906) extended to January 31, 1908.

The terms of all the above leases were similar, the rental paid being a royalty of 18 cents per ton upon all the stone quarried and crushed.

The rock from this ledge is sound, hard and of excellent quality. The stripping required to uncover the rock amounted in 1905 to 17 per cent and in 1906 to 19 per cent of the whole quantity taken out and paid for. This is not regarded as excessive.

The plant consists of one 10-inch by 16-inch and one 9-inch by 15-inch jaw crusher, the former being now twenty years old and the latter eleven years old. The rated capacity of the former is about 100 tons per day and of the latter about 80 tons per day. Both are now practically worn out. There is one 11-inch by 16-inch and one 9-inch by 12-inch engine, with boiler and other necessary machinery. The storage bins have a capacity of about 170 tons. The whole plant is old but in fair condition.

According to the city records the cost of this plant was $7,976. But this is incomplete, the machinery brought from other plants not being charged up to this plant. Mr. Cole's estimate of the original cost of the plant amounts to $13,572. His estimate of its present value is $5,747. The depreciation for the eleven years since the plant was erected has been about 58 per cent, or about 5½ per cent per year.

Operation.

Contracts for quarrying and delivering rock to the crusher appear to have been made as follows: The price named was paid for all material excavated, both rock and earth stripping. Under the Vallen contract the city operated the power drills at its own expense in addition to paying Vallen 80 cents per ton.

September 1, 1896, T. Minton	70 cents per ton.
August 2, 1897, T. F. Minton	70 cents per ton.
May 14, 1900, E. Vallen	80 cents per ton.
December 4, 1901, James A. Mahon	80 cents per ton.
July 26, 1902, T. F. Minton	70 cents per ton.
April 20, 1904, T. F. Minton	70 cents per ton.

The last contract was extended to February 1, 1906. Another contract was signed September 4, 1906, with Thomas F. Minton, the price being 70 cents per ton.

According to the city records the output and cost of producing stone for the ten fiscal years 1897 to 1906, inclusive, is shown in the following table. Interest and depreciation has been added to show the complete cost.

Table No. 4.

YEAR.	Output, Tons of Crushed Stone.	COST FROM CITY RECORDS.		(COST, $13,572.) INTEREST, 4 PER CENT. DEPRECIATION, 5½ PER CENT.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1897	20,052	$35,206	$1 756	$1,289	$0 064	$1 820
1898	31,510	30,023	952	1,289	041	993
1899	15,585	32,587	2 090	1,289	083	2 173
1900	17,027	36,477	2 140	1,289	075	2 215
1901	7,683	12,912	1 682	1,289	168	1 850
1902	19,688	42,393	2 153	1,289	065	2 218
1903	32,428	33,530	1 034	1,289	040	1 074
1904	29,345	58,163	1 982	1,289	044	2 026
1905	48,593	58,727	1 207	1,289	026	1 233
1906	13,765	31,474	2 286	1,289	094	2 380
Totals	235,676	$371,492	—	$12,890	—	—
Averages	23,568	37,149	$1 577	1,289	$0 055	$1 632

Considering the operations for the calendar years 1905, 1906 and 1907 more in detail, based so far as practicable on the city records, we have the following itemized cost per ton of crushed stone produced:

Table No. 5.

ITEMS OF COST.	1905.	1906.	1907.
Output in tons	47,969	14,389	1,099
Interest and depreciation ($1,289)	$0 027	$0 090	$1 17
Rental, royalty paid	161	180	18
Quarrying	927	908	70
Labor	160	556	4 66
Teams	—	050	13
Coal, oil and light	030	051	67
Repairs	059	050	1 04
Sundry items	—	—	02
	$1 364	$1 885	$8 57

The labor charge per ton in 1906 was excessive and is unexplained. Either the charges must have been improperly entered on the books, or labor done on other work was charged to this crusher, or the pay rolls were padded.

The labor charge for 1907 is so grossly excessive that it cannot be explained by mere mismanagement. It will not be commented upon in detail here, but the matter of these enormous labor charges at the various crushers in 1906 and 1907 will be considered together later on.

The actual expenditures at this plant in 1907, as taken from the city records, were as follows:

Rental (royalty)	$197 85
Quarrying	769 42
City labor	5,113 55
Teaming	143 00
Coal, oil and light	737 06
Repairs	1,150 16
Sundry items	15 96
Total	$8,127 00

According to the record kept at the crusher there was on hand at this crusher on January 1, 1907, 11,896 tons of crushed stone.

CHESTNUT HILL AVENUE CRUSHER.

This crusher is located on Chestnut Hill avenue, Brighton, between Cheswick and Wallingford roads.

A crushing plant was apparently built on this property as early as 1883. The annual report for that year states that the cost of setting up a crusher and a building to protect it was $1,043. The crusher erected at that time is said to have been an old one brought from Cambridge street, Brighton.

The present plant was erected in 1898. The additional machinery for it probably came from the Kenney ledge in Roxbury, but no definite information on this point is obtainable. There seems to be no record of the disposition of the original crusher and other machinery.

Description.

This lot upon which this crusher is located is owned by the city. It was purchased in 1882 for $30,000, its assessed value at the time being $20,000. It was valued by the tax assessors in 1907 at $79,800, exclusive of buildings and plant. The deed to the property calls for 569,776 square feet, but the Street Department reports give the area of the property at 601,563 square feet, or about 13.8 acres. The area as determined from the best maps available indicate that the area is 536,700 square feet.

The property is used as the yard and headquarters of District 4, as well as for the crusher plant.

The rock in this ledge is a hard pudding-stone, full of seams, easily quarried, but requiring considerable sledging to reduce the masses to a suitable size for the crusher. The stone is of excellent qualitv for macadam roads. The stripping or earth covering over the ledge has been comparatively light; in 1905, 90 per cent of the whole excavation was rock, and in 1906 no stripping at all was reported. There is apparently still a large quantity of rock on the property available for crushing.

There is but one crusher at this plant, a 30-inch by 13-inch Farrell machine. The engine is a 12-inch by 16-inch slide valve "Atlas," and the tubular boiler is 66 inches by

17 feet. The plant is in fair condition, though most of the machinery is old, having been in use before it was erected here. The storage bins have a capacity of approximately 400 tons.

The city accounts do not show the true cost of this plant, as the machinery, etc., brought from other localities was not charged up. The only record is that the cost of erecting the plant amounted to $3,623. Mr. Cole estimated its cost as $16,653. He estimates its present value as $6,681, a total depreciation of 60 per cent, or at the rate of about 6¾ per cent per year. The rate of depreciation is figured low because the plant can be operated for several years without removal.

The estimated capacity of the plant is 300 tons per day crushed to 2½-inch size.

Operation.

The rock at this crusher has, as in nearly all other cases, been quarried and delivered to the crusher by contract. The following contracts are of record:

With M. Kiernan, September 10, 1896.
With M. Kiernan, May 28, 1897.
With M. Kiernan, August 20, 1902. (Extended to April 20, 1904, to February 1, 1906.)
With Coyle & Clark, October 11, 1907.

In addition to the stone quarried by contract it appears that about 1,000 cubic yards of stone was delivered to this crusher in 1899 and 1900, from Cambridge street, by the contractor for grading that street, the cost being charged up to that street, and not to crushed stone. Also it appears that a large quantity of rock excavated from Commonwealth avenue was delivered to this crusher, but the records are so incomplete and indefinite that the details are not obtainable. The cost of excavating and delivering the rock seems to have been charged to the construction of Commonwealth avenue.

The dates of expiration of these quarrying contracts are not usually given, and it is not known whether the contracts to Kiernan covered the whole period from 1896 to 1907. The

price paid under all these contracts was 70 cents per ton for all the material excavated, whether rock or stripping, the city furnishing free the steam to operate the power drills.

The quantity of crushed stone produced by this plant and the cost of operation as recorded in the city ledger for the fiscal years 1897 to 1906, inclusive, are shown in Table 6.

Additional columns show the charge to interest and depreciation and the deduced total cost per ton for each year.

Table No. 6.

Year.	Output, Tons of Crushed Stone.	Cost from City Records.		(Cost, $16,653.) Interest, 4 Per Cent. Depreciation, 6¼ Per Cent.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1897	18,869	$23,818	$1 262	$1,791	$0 095	$1 357
1898	1,473	4,485	3 045	1,791	1 215	4 260
*1899	788	1,240	1 574	1,791	2 272	3 846
*1900	4,616	5,758	1 247	1,791	388	1 635
1901	18,597	31,547	1 695	1,791	096	1 791
1902	19,655	29,126	1 482	1,791	091	1 573
1903	43,028	31,889	741	1,791	042	783
1904	23,976	40,452	1 688	1,791	075	1 763
1905	33,575	35,615	1 061	1,791	053	1 114
1906	3,012	8,537	2 832	1,791	595	3 427
Totals	167,589	$212,467	—	$17,910	—	—
Averages	16,759	21,247	$1 267	1,791	$0 107	$1 374

The details of cost per ton for the calendar years 1905 and 1906 differ somewhat from those given in the previous table for the fiscal years, and, with those for 1907, are as follows:

* In these years about 1,000 cubic yards of stone quarried from Cambridge street and Commonwealth avenue were delivered to this crusher by the contractors for constructing these streets. This was probably charged to Cambridge street, and the crusher account was reduced by the amount that would otherwise have been paid for quarrying it.

Table No. 7.

ITEMS.	1905.	1906.	1907.
Quantity of output, calendar year (tons)	32,864	2,483	9,056
Interest and depreciation ($1,791)	$0 055	$0 722	$0 198
Rental, royalty paid	—	—	—
Quarrying	801	187	536
Labor	132	2 459	432
Teams	068	463	081
Coal, oil and light	043	227	131
Repairs	040	039	074
Sundry items	009	080	002
Totals	$1 148	$4 177	$1 454

A large part of the stone crushed in 1906 and 1907 was not quarried at this ledge but was hauled to the crusher from other points. This accounts for the low cost of "quarrying."

The plant was operated 129½ days in 1905.
The plant was operated 31½ days in 1906.
The plant was operated 98 days in 1907.

According to the books kept at the crusher the crushed stone

On hand on January 1, 1906, was	23,080 tons.
There was crushed during 1906	2,483 tons.
Total	25,563 tons.
There was sent out in 1906	14,678 tons.
Leaving a balance on January 1, 1907	10,885 tons.

But during the year 1906 a measurement of the stored stone was made by the city engineer's office which gave 2,744 tons less than there should have been by the crusher books; deducting this leaves, as actually on hand January 1, 1907, 8,141 tons.

The crusher books actually show, however, that the quantity on hand January 1, 1907, was 8,055 tons.

The comparatively low cost of crushed stone in 1905 is partly due to the fact that the city owns the ledge and, therefore, pays no royalty on the rock.

The city did all the quarrying at this ledge in 1906, and the labor on this work was probably not all charged to that account; hence the apparently low cost per ton for quarrying.

The total quantity of crushed stone produced at this crusher in 1906 was but 2,843 tons. The city books show charges against the crusher for that year as follows:

Quarrying stone	$464
Labor	6,101
Teams	1,150
Coal, oil and light	563
Repairs	98
Supplies	200
Total	$8,576

Something is evidently wrong with the accounts for the operation of this crusher for this year (1906). The quantity of stone turned out should not have required the operation of the plant more than ten days at the outside, and it is impossible that the sums above could have been expended upon the quantity of work done.

CODMAN STREET CRUSHER.

This crusher is located on Codman street at Hillsdale street, Dorchester.

A crushing plant was first erected on this lot in 1871 at a cost of $3,850, and continued in operation until the present plant was built.

The present plant was erected in 1903–04, a large part of the machinery used being moved from the Mosman crusher plant in Roxbury.

The city owns the lot on which this crusher is operated. The property was purchased by the city in 1870 for $5,988. Its present value is estimated by the city to be $15,000.

An additional lot adjoining the property previously owned was purchased by the city, May 6, 1907, from Elias A. Perkins, for $13,370.60. Its assessed valuation in 1907 was $5,200. Its area is stated to be 104,280 feet.

The value of this lot for crusher purposes is not great, as estimates recently made show that there is on the lot only

about 4,500 cubic yards of rock above a grade one foot higher than the grade of Codman street. The city already had abundant storage room at this plant, so that additional land was not needed for that purpose.

This was a good ledge with a high face and the rock was of good quality. The supply is now almost exhausted from the original lot, but there is an abundance of good rock on adjacent property not owned by the city.

There was practically no stripping required.

Description.

There are two Farrell crushers here, one 30 inches by 13 inches and one 9 inches by 15 inches, both being in fair condition.

The capacity of the plant is rated at 300 tons per day.

The city records show that the cost of moving machinery and buildings from the Mosman ledge and setting it up on the new site, together with new machinery bought, was $25,169. But there is no inventory of the machinery so moved nor was its value charged to the new plant. As nearly as can now be determined the value of the machinery, etc., brought from the Mosman ledge was $6,702, which should be added to the amount expended by the city, $25,169, making the total cost of the plant $31,871.

The city books show that new machinery costing $6,204 was purchased. Adding this to the value of that brought from the Mosman ledge, $6,702, we will have as the cost of the machinery for the plant $12,906, and deducting this from the total cost there remains a balance of $18,965, which must have been expended for erecting the machinery and putting up the buildings. These figures indicate that the cost of the buildings and the erection of the machinery was grossly excessive.

Mr. Cole's estimate of the cost of the plant when erected was $22,350, of which the buildings were estimated to cost $7,274. Upon the basis of Mr. Cole's inventory the plant must have cost the city $9,521 more than it should have cost.

Mr. Cole's estimate of the present value of the plant is $15,633. The total depreciation according to his cost figures is 30 per cent, and according to the cost as given in the city

books, is 51 per cent, or at the rate of about 12¾ per cent per year.

The following contracts for quarrying and delivering rock to crushers are of record:

July 23, 1892, James F. Davern	70 cents per ton.
April 29, 1902, James A. King	75 cents per ton.
April 29, 1902, John Bradley	75 cents per ton.
June 13, 1902, Patrick McGovern	70 cents per ton.

McGovern continued to quarry and deliver rock through 1905 and a part of 1906 at same price.

The plant was operated:

During the year 1905	165 days.
During the year 1906	30 days.
During the year 1907	25 days.

The old plant seems to have been operated every year before the new plant was erected, and in order to get a general idea of results at this plant for the past ten years we will first consider the data for the whole period.

Table No. 8.

Fiscal Year.	Output, Tons of Crushed Stone.	Cost from City Records.		(Cost, $31,871.) Interest, 4 Per Cent. Depreciation, 12¾ Per Cent.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1897	18,498	$27,713	$1 500	$5,328	$0 289	$1 789
1898	16,127	13,601	844	5,328	331	1 175
1899	11,163	15,704	1 407	5,328	478	1 885
1900	13,975	17,232	1 233	5,328	382	1 615
1901	10,519	19,942	1 895	5,328	507	2 402
1902	32,437	53,536	1 650	5,328	164	1 814
1903	42,733	44,284	1 036	5,328	125	1 161
1904	19,911	45,771	2 300	5,328	268	2 568
1905	50,140	50,979	1 016	5,328	106	1 122
1906	1,043	14,200	13 610	5,328	5 118	18 728
Totals	216,546	$302,962	—	$53,380	$0 246	—
Averages	21,655	30,296	$1 400	5,338	246	$1 646

The details of cost per ton for the calendar years 1905, 1906 and 1907 differ somewhat from those given in the previous table for the fiscal years, and are as follows:

Table No. 9.

ITEMS.	1905.	1906.	1907.
Quantity of output for calendar year	47,129	2,874	1,004
Interest and depreciation ($5,338)	$0 113	$1 855	$5 314
Quarrying	904	341	043
Labor	144	2 835	2 706
Teams	034	182	115
Coal, oil and light	035	063	264
Repairs	039	065	097
Sundry items	018	—	018
Totals	$1 287	$5 341	$8 557

The gradual enhancement in value of the real estate, if it could be accurately determined, would decrease these costs slightly but not materially.

Among the charges to this plant for 1905 is an item of $832 for rent and expense of extra boiler, presumably used to supply steam to the rock drills. The rental appears exorbitant, as a good new boiler could have been bought for less than the rental paid for a single year.

According to the City Hall records the quantity of stone crushed at this plant in the fiscal year 1906 was only 1,043 tons. During the calendar year the quantity was 2,874. Yet charges against this crusher for that calendar year are found on the city ledgers, as follows:

Repairs	$188 33
Coal, oil and light	181 30
Teams	522 50
Labor	8,145 46
Quarrying	979 70
Total	$10,017 29

Of course no such sum could have been honestly spent to crush less than 3,000 tons of stone. Either there was gross

carelessness in the bookkeeping or a gross fraud was perpetrated against the city. The charges for labor during the preceding year, when 47,129 tons were produced, was $6,670, or $475 less than in 1906, when only about 3,000 tons were produced. This matter will be further considered later in this report.

The showing for the calendar year 1907 is even worse than for 1906. The amounts charged up to this plant for that year are:

For quarrying	$42 87
City labor	2,716 64
Teams	113 50
Coal, oil and light	264 85
Repairs	97 08
Sundry items	17 90
Total	$3,252 84

The item of labor alone here amounts to $3.24 for every ton of stone crushed.

As the yard of the twelfth district is on the same lot with this crusher, it is possible that some of the labor charged to the crusher may have been expended on other work, in connection with the district yard, but there are no records to sustain such an assumption.

According to the records at the crusher, there were 17,768 tons of crushed stone on hand at this crusher on January 1, 1907. A measurement made by the city engineer's office of the quantity of stored stone during the year 1906 showed 3,396 tons less than should have been there by the crusher books. The true quantity on hand January 1, 1907, should, therefore, be 14,372 tons.

COLUMBIA ROAD CRUSHER.

This crusher is located on Columbia road, at Brunswick street.

No crusher existed at this site previous to 1901.

The lot was first leased by the city from the trustees of the Franklin King estate on March 22, 1901, for a period of five years. Under the terms of this lease the city was required

to pay a royalty of ten cents per ton for all material excavated and used upon the streets, whether rock or earth. The city agreed to excavate Intervale street to grade within two years, and to excavate the whole tract to the grade shown on an attached blue print within the life of the lease.

Correspondence on file between the Superintendent of Streets and the city Law Department indicates that one incentive to the rental of this property as a crusher site was the fact that the owners of the property had claimed $40,000 damages for the construction of Columbia road through the property. But it is said that in consideration of the city leasing the property and agreeing to grade it, a settlement of the damages claimed was effected for $7,529.04.

Further correspondence following the execution of this lease shows that the Superintendent of Streets signed this lease without any adequate study of its contents. It was found among other things that the land covered by the lease embraced only the ledge proper and did not include that needed for the location of the crushed plant. The correspondence resulted in the execution of a supplemental lease dated June 12, 1901, extending the boundaries of the property leased, but also stipulating that the city must not crush any stone at this plant not quarried from the leased ledge.

On March 8, 1906, authority was given by the Mayor to extend these leases for a period of two years, and also to lease an adjoining tract from the same estate, the royalty to be paid for all material taken out and used from all the property to be 12½ cents per ton, and such an extension was executed on December 29, 1906.

The first lease required that the city should excavate the whole property to grade by the date of expiration, March 20, 1906. This the city failed to do, nor was it prepared at that time to remove the crusher plant. In consideration of this failure and the extension of the lease for two years, the city agreed in the last extension, December 29, 1906, to pay the King estate $1,000 in addition to the royalty of 12½ cents per ton for all material taken out thereafter, and also to complete the excavation of the whole property leased, down to the grade designated, within the two years' extension.

But there was a proviso that the city should have a further three months' extension if needed. This present lease, with the three months' additional time provided for, will expire on June 22, 1908.

This second extension of the lease (dated December 29, 1906) seems to have been a very peculiar business transaction. It can be readily understood that an extension of the leases was desirable in order to allow time for the city to fulfill the obligations it had entered into relating to the grading of the lot. It may have been thought expedient to increase the royalty to be thereafter paid in order to avoid possible damages for the nonfulfillment of these obligations; but it is difficult to understand why these obligations should have been enlarged and greatly increased by the extension of the lease over additional territory, particularly as this additional territory was undesirable for quarrying purposes. The additional area to be excavated over thus brought into the lease was about 95,000 square feet. While the elevations of the original or natural surface of this added area are not known, there is reason to believe that the thickness of the rock, down to the plane to which it was to be excavated, was not sufficient for economical quarrying, and that the depth of overlaying earth was so great as to make the ratio of stripping to rock very high. This is indicated by the fact that all the excavation on this added tract was done in 1906 and 1907, during which years the average percentage of stripping was over 40 per cent, so that at 70 cents per ton, paid for both rock and stripping, the quarrying of the rock and its delivery to the crusher cost the city about $1.17 per ton.

The rock from this ledge has generally been hard and good, but the part now being worked is comparatively near the surface of the ledge, is "weathered" and a considerable part of it is of poor quality. The stripping over the part now being worked will average from four to five feet thick.

Description.

This is the largest and most complete of the city crusher plants, and new machinery only was installed when the plant was built. The crusher (Farrell) is a 36-inch by 18-

inch machine. The engine is an "Atlas," 16-inch by 24-inch cylinder, rated at 100 horse power. The boiler is 72-inch by 18-inch tubular. All other usual accessories are provided. The storage bin has a capacity of about 720 tons. The plant is in good condition and when visited was doing good work.

Its capacity is estimated by the city at 500 tons per day, but the builders of the crusher give its capacity when crushing to 2½-inch size at 450 tons per 10-hour day.

The cost of this plant, according to the city ledgers, was $35,117. Mr. Cole's inventory estimates the cost of building it as $30,968, but there is included in this sum a few items purchased since the plant was first constructed. The difference between the actual cost to the city and Mr. Cole's estimate is $4,149. So far as can now be determined the prices paid by the city for machinery agree quite closely with Mr. Cole's estimate, and the additional cost to the city must have been due to excessive cost of materials and labor for the buildings and for the erection of the plant. According to Mr. Cole's inventory the cost of the machinery erected was $19,672. If we subtract this sum from the cost of the plant according to the city records it would indicate that the buildings and the erection of the machinery must have cost $15,445, which is grossly excessive. The present value of the plant, according to Mr. Cole's estimate, is $13,208.

Operation.

This plant was operated:

191 days in 1905; 123 days in 1906; 81 days in 1907.

The first contract for quarrying was made with James F. Davern dated June 18, 1901. The price paid for quarrying and delivering the rock to the crusher was to be 80 cents per ton. It is not clear whether this price was to be paid for both rock and stripping or for the rock alone, but the evidence indicates that only the rock was paid for. This contract was cancelled May 8, 1902.

A contract was then made, May 15, 1902, with H. P. Nawn for two years. Under this contract the city was to pay 70 cents per ton for all material excavated (both rock and earth) and the city was to supply steam for the operation of

the power drills. This contract was (April 20, 1904) extended to February 1, 1906, but was cancelled April 12, 1905. The contract price covered only the quarrying and delivery of the rock to the crusher platform, but the contractor was to supervise the feeding of the rock to the crusher, and the city was to allow and pay him for not more than three men at $2 per day each for feeding the rock into the crusher. On April 12, 1905, a contract was made with George W. Reagan, the terms being the same as under the preceding contract. On May 2, 1906, a contract was made with D. F. O'Connell, on same terms as preceding. This contract was cancelled August 6, 1907. Another contract was then made, September 3, 1907, with James A. Mahon (though it appears that Mahon began work in August, 1907) under the same terms as the preceding contracts (except some minor details). This contract has recently been suspended (January 3, 1908).

It will be noted that the price for quarrying has been uniformly 70 cents per ton for all material taken out since May, 1902, notwithstanding that the ratio of stripping to rock must have been greatly increased recently. In 1906 44 per cent and in 1907 nearly 35 per cent of all the material taken out and paid for at 70 cents per ton was earth stripping.

As further illustrating the carelessness of the department in dealing with contracts of this character the following incident may be mentioned. It seems that when the contract with James F. Davern was cancelled he had roughly blasted out a lot of rock which had not been completely broken up, and had not, of course, been delivered to the crusher. Davern claimed some compensation for this work, and after a proper and careful investigation he was awarded and was paid the sum of $2,600.

When the succeeding contract was made with Nawn the matter of this partially done work was apparently overlooked, or at least nothing was said about it in the contract. Subsequently Nawn asserted that the work done by Davern was of no value to him, and claimed the full contract price for it, and after some negotiation his claim was allowed and he was paid the full contract price for this work which was already partly done.

The city records show the following results of operating this crusher, the years being the fiscal years. I have added columns giving the interest and depreciation charges.

Since this plant will have to be torn down and removed very soon the depreciation charge is necessarily high.

According to Mr. Cole's inventory of cost and present value the total depreciation figures nearly 57 per cent, but if we use the city figures for cost and Mr. Cole's estimate of present value, the total depreciation has been 62 per cent, or 10.3 per cent per year, and this figure is used in computing the following table:

Table No. 10.

YEAR.	Crushed Stone, Tons.	COST OF OPERATION.		(COST, $35,117.) INTEREST, 4 PER CENT. DEPRECIATION, 10.3 PER CENT.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1901	23,992	$29,382	$1 225	$5,022	$0 209	$1 434
1902	50,627*	78,974	1 559	$5,022	099	1 658
1903	68,854†	82,332	1 195	$5,022	073	1 268
1904	31,269‡	67,254	2 152	$5,022	161	2 313
1905	54,418	68,728	1 262	$5,022	092	1 354
1906	31,981	74,956	2 342	$5,022	157	2 499
Totals	261,141	$401,626	—	$30,132	—	—
Averages	43,524	66,938	$1 537	5,022	$115	$1 652

* 3,770 tons of Telford also quarried.
† 6,520 tons of Telford also quarried.
‡ 1,370 tons of Telford also quarried.

The details of cost per ton for the calendar years 1905, 1906 and 1907 differ somewhat from those given in the preceding table for the fiscal years, and are as follows:

Table No. 11.

ITEMS.	1905.	1906.	1907.
Output for calendar year (tons)	54,195	32,561	19,050
Interest and depreciation ($5,022)	$0 093	$0 154	$0 264
Rental (royalty)	105	154*	125
Quarrying	908	1 328	1 084
Labor	232	461	616
Teams	029	066	092
Coal, oil and light	034	053	058
Repairs	066	021	093
Sundry items	012	026	096
	$1 479	$2 263	$2 428

* $1,000 paid as damages is included in the royalty paid for this year.

The actual amounts charged on the city books to this crusher for the calendar years 1906 and 1907 were as follows:

	1906.	1907.
Rental (royalty)	$5,032 63	$2,393 73
Quarrying	41,734 25	20,647 97
Labor	16,399 48	11,736 87
Teams	2,157 50	1,753 00
Coal, oil and light	1,715 65	1,096 65
Repairs	767 91	1,773 36
Sundry items	852 35	1,836 69
	$68,659 77	$41,238 27

Some other Facts Relating to this Plant.

The amount paid as royalties on this property, based upon the quantities of rock taken out, should be as follows:

On 229,160 tons taken out up to March 8, 1906, at 10 cents	$22,916
On 31,981 tons taken out from March 8, 1906, to December 31, 1906, at 12½ cents	3,998
On 11,760 tons of Telford stone at 10 cents (?)	1,176
Total	$28,090
To this should be added the $1,000 paid as damages for failure to grade the lot within contract time	1,000
Total	$29,090

This agrees approximately with the total payments shown by the city ledgers to have been made to the lessors for stone taken out previous to January 1, 1907, which aggregates $29,187.

No account is here taken of the $7,529 paid as a compromise settlement for damages by the construction of the Columbia road, paid at the time the property was leased.

Taking the figures as given above, it appears that the average annual payment for royalty was $4,850. The assessed valuation of the whole property (409,558 square feet) in 1901 was $61,400, and the return received by the lessor on this value has been at the rate of very nearly 8 per cent. But the value of the property must have been considerably increased by the grading operations of the city. What this increase has been I have no means of determining accurately. The assessed value of the same property in 1907 was $65,500, an increase of $4,100, or about 6.7 per cent.

Some light is thrown upon the question of the enhancement of value of the property by the assessed valuation of the properties on each side of it. The tract adjoining it on the north was assessed in 1901 for $106,600 and in 1907 for $65,100, a decrease of $41,500, or 38½ per cent. The tract adjoining it on the south was assessed in 1901 at $3,400 and in 1907 at $3,100, a decrease of $300, or 8.8 per cent. It is hardly likely that these adjoining properties have actually decreased in value, and in view of the above relative range of assessments it would seem reasonable to assume that this quarry tract has been increased in value by the city's operations at least 20 per cent. The fair market value of the property in 1901 is not known, but if the city had purchased it at that time for 50 per cent more than its assessed value, or, say, for $90,000, the interest charges at 4½ per cent would have amounted to considerably less than has been paid out for royalty, and the city would have had the benefit of the enhancement of value due to its own work of grading down the property.

There is a further complication with regard to the grading of the property which may result in a large claim for damages by the lessors, or in a large additional cost for grading to the

city. The leases provide that the property is to be graded down to a certain level shown on the plans attached to the original lease. It is now claimed by the lessors that the city has not complied with this condition and that about two feet in depth remains to be excavated to bring the rock surface down to the prescribed level. Also that the city has not carried the excavation out to the boundaries of the lot. This claim is made in a letter from the attorneys of the lessors, dated December 17, 1907, and the presumption is reasonable that this letter was intended to lay a foundation for a subsequent claim for damages. Levels recently taken by the city engineer's office indicate that there is substantial ground for the claim of the lessors over at least a part of the area, but the levels were not sufficiently complete to determine the matter accurately. It would obviously be a very costly operation to go over any considerable part of the area of the lot and remove so thin a stratum of rock.

Attention has already been called to the fact that Mr. Cole's estimated first cost of constructing this plant is considerably less than the cost shown by the city ledgers. Mr. Cole's estimate is, in my opinion, very liberal, and I believe the city could have contracted for the construction of the plant complete, under proper specifications, for a sum not exceeding $25,000. This does not include some of the buildings now connected with the plant, such as the stable, blacksmith shop, etc., built later, nor the extra parts on hand, presumably purchased since the plant was built. The conclusion seems justified that the plant cost the city at least $5,000 more than it should have cost.

Several elements enter into the cost to the contractor of quarrying the rock and delivering it to the crushers. In most cases more or less stripping is necessary (which consists in removing and disposing of the earth that overlays the ledge or rock). The stripping at the Columbia ledge is ordinary clay and soil, which has averaged for the past two years about five feet in depth. It is loaded into carts and hauled and deposited in the depressions from which the rock has been excavated. The haul cannot have averaged during 1905 and 1906 more than 800 feet.

The cost of excavating and disposing of this stripping should not have exceeded 20 cents per ton, and probably did not exceed 15 cents per ton.

The cost of excavating the rock should not exceed 35 cents per ton and the cost of loading it into carts and hauling it to the crusher should not exceed 30 cents per ton, making the total cost for the rock delivered at the crusher 65 cents per ton.

Applying these estimated cost prices to the work of 1906, we shall have:

25,714 tons of stripping at 20 cents	$5,143
32,460 tons of rock delivered at 65 cents	21,099
58,174 tons of stripping and rock, costing	$26,242

making an average of slightly over 45 cents per ton for all the material.

This estimate is fairly well confirmed by available memoranda relating to the actual work on the ledge. The inspector at the plant makes a daily report of the number of men actually at work for the contractor in the quarry and feeding the crusher. These records during the time when D. F. O'Connell had the contract for quarrying and delivering rock, covering the period from May 2, 1906, to date of suspension of his work, October 31, 1906, have been collected. Applying to the various classes of work the prevailing rates of wages, the account may be made up as follows:

Sub-foreman, 212 days at $5.50	$1,166 00
Clerk, 230.6 days at $3	691 98
Carpenter, 2 days at $3.50	7 00
Watchman, 4 days at $2.25	9 00
Blacksmith, 223 days at $3.50	780 50
Blacksmith's helper, 216 days at $2.50	540 00
Steam drillers, 460 days at $3	1,380 00
Hand drillers, 1,026.8 days at $2	2,053 76
Helpers, 484.1 days at $2.25	1,089 25
Stone breakers, 1,478 days at $2	2,956 00
Powder men, 200 days at $3	600 00
Timekeeper, 8.16 days at $2	16 22
Water boy, 180.2 days at $2	360 00

Laborers, 2,664.7 days at $2	$5,329 40
Single teams, 913 days at $3	2,739 00
Double teams, 509 days at $5.50	2,799 50
Total	$22,517 61
In this is included sums paid for work other than quarrying to the amount of about	1,000 00
Leaving as the net cost	$21,517 61

To this should be added the following items:

For explosives used, say	2,500 00
Supplies, repairs and general expenses	2,000 00
Total	$26,017 61

The quantity of material quarried by O'Connell was 32,460 tons of rock and 25,713 tons of earth, making in all 58,173 tons, and the average cost per ton would be about 45 cents.

It is therefore safe to say that the actual cost to the contractor of quarrying and delivering this stone and stripping did not exceed 45 cents per ton; and if so his profit must have been 25 cents per ton, or, for the whole work done, the total profit must have been:

58,173 tons at 25 cents	$14,543

Considering that the work was all done in about six months, this was a very good business.

There can be no reasonable doubt that if the city had at the beginning of operations on this ledge invited bids for quarrying and delivering the rock to the crusher, covering the whole period while the work was to be in progress, it might have contracted for the work at a price per ton for both rock and stripping not exceeding 50 cents per ton. The total quantities excavated, up to the end of 1906, foot up 308,560 tons, and the saving of 20 cents per ton would have amounted to the sum of $61,712.

Excessive Cost in 1906.

The itemized cost of operating this plant for the calendar year 1906 was as follows:

Rental (royalty)	$5,032 63
Repairs and maintenance	767 91
Fuel, oil and light	1,715 65
Teams	2,157 50
City labor	15,010 75
Hire of extra boiler	852 35
Quarrying rock and extras	23,554 74
Quarrying strippings	18,179 51
Extra contract labor, platform	862 00
Extra contract labor, dump	385 50
Extra contract labor, bins	70 00
Extra contract labor, miscellaneous	71 23
Total	$68,659 77

The plant was operated during this year 123 days, and turned out 32,561 tons of crushed stone.

The item for city labor, $15,011 above, excites curiosity and needs explanation. Divided over 365 days it amounts to slightly over $41 per day, while if divided over the 123 days that the plant worked it amounts to $123 per day. Neither of these divisions are, however, correct. A certain force of men, such as watchmen, and, it appears, the weighers, engineers and foremen, are employed constantly whether the plant is running or not, but the exact amount thus chargeable is not known.

While the plant was running in November, 1907, the following city force was found at the plant:

1 Inspector at $3	$3 00
1 Sub-foreman at $3.50	3 50
1 Weigher at $2.25	2 25
1 Clerk at $2.25	2 25
1 Engineer at $3.50	3 50
2 Firemen at $2.83	5 66
1 Oiler at $2.25	2 25
3 Watchmen at $2.25	6 75
2 Laborers at $2.25	4 50
Total	$33 66

making a total pay roll account of $33.66 per day. This does not include the three men feeding the crusher, who were carried on the contractor's pay roll. The above is an unnecessarily large staff to operate such a plant, but if the

whole of them were paid for 300 days' work per year it would amount to only $10,098 per year, leaving about $5,000 of the total labor charge for 1906 to be otherwise accounted for.

For what purpose this enormous charge for labor was expended cannot be determined from the city accounts. It has been suggested that it might have been employed in quarrying rock, but if so the contractor got the benefit of it, for he was paid at his contract price for all except about 100 tons of the rock taken out and crushed during the year.

The charge for teams ($2,157.50) is also difficult to account for. These teams are supposed to be employed to haul crushed stone from the bins when they would otherwise be overloaded and store it in piles on the grounds. The distance hauled does not exceed 300 or 400 feet, and the quantity it is thus necessary to move and store should have been only a small fraction of the whole. Yet the total sum charged for teams amounts to 6.6 cents per ton for *all* the stone crushed that year. The cost, if all the stone had thus been hauled and stored, would not exceed 12 cents per ton, and should be considerably less. Other of the items charged for in the year's work are exorbitant, but they need not be taken up in detail. An extra boiler, presumably intended to furnish steam to the rock drills, but not now so used, appears to have been rented at a cost for the year of $852.35. A suitable boiler for the purpose could have been bought outright for about half that sum. Notwithstanding the abundant force of the city at the crusher it appears that the contractor was paid during the year $526.73 for extra work on dumps, bins, etc.

With such extravagant (or worse) management it is not surprising that the output of the crusher for the year cost $2.26 per ton. The cost for 1907 was still higher, $2.43 per ton, but all the details necessary for a full discussion of that year's work are not at hand.

DIMOCK STREET CRUSHER.

This crusher is located on Washington street, near Dimock, Roxbury.

It was originally built in 1874. The city records show that in 1882 another crusher was added to this plant at a cost of $1,868 and a new building put up at a cost of $1,044. No record can be found of additions to the plant since that date.

The lot and ledge upon which the crusher is located was purchased by the city previous to 1870. The purchase price is not known. The area of the property is 134,671 square feet, or a little over three acres. The assessed valuation of the lot in 1907 was $67,300. The rock ledge being practically exhausted, the lot is now only useful to the city as a storage yard. It might be profitably sub-divided and sold in building lots.

Description.

The two crushers are each 15 inches by 9 inches, Farrell, very old. The engine and boiler are also old and now of little value. The fact that the ledge is exhausted and the worn-out condition of the plant makes its present value very small. It is not worth moving and is, therefore, worth only what it would bring as scrap. There is practically no storage capacity. Its capacity was rated at 80 tons per day.

So far as can be learned from the city books the original cost of this plant, in 1874, was $1,283, but the accounts are doubtless incomplete. In 1882 a new crusher was added and a new building erected at a cost of $2,912.

Mr. Cole's inventory estimates the first cost of the buildings and machinery now on hand as $9,522. Its present value does not exceed $2,000. It is difficult to fix any rate of depreciation extending over the long life of this plant without accurate details of the additions and replacements that have been made in the meantime. But it will be conservative to assume a rate of depreciation of 7 per cent.

Operation.

Contracts for quarrying and delivering rock to the crusher are of record as follows:

With H. P. Nawn, April 22, 1891	87 cents per ton.
With H. P. Nawn, July 30, 1892	90 cents per ton.
With P. F. Lanergan, March 28, 1895	79 cents per ton.
With H. P. Nawn, April 13; 1896	80 cents per ton.
With John F. Cullen, April 14, 1902	78 cents per ton.
With John F. Cullen, May 9, 1902	75 cents per ton.
With Mark H. Lynch, April 30, 1904	70 cents per ton.

Since 1905 nearly all the rock crushed at this plant has been brought from other localities, the ledge being exhausted.

Taking the ten fiscal years 1897 to 1906, inclusive, the output and cost of producing crushed stone at this plant, as shown by the city accounts, has been as given in Table 12. The total cost with interest and depreciation charges added being shown in the last column.

Table No. 12.

Fiscal Year.	Output, Tons of Crushed Stone.	Cost from City Records.		(Cost, $9,522.) Interest, 4 Per Cent. Depreciation, 7 Per Cent.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1897	37,265	$52,430	$1 407	$1,047	$0 028	$1 435
1898	16,362	32,991	2 015	1,047	064	2 079
1899	22,088	25,432	1 152	1,047	047	1 199
1900	26,204	37,704	1 438	1,047	040	1 478
1901	17,697	25,065	1 416	1,047	059	1 475
1902	22,668	46,306	2 044	1,047	046	2 090
1903	5,103	22,056	4 324	1,047	205	4 529
1904	22,461	29,911	1 331	1,047	047	1 378
1905	6,687	9,728	1 455	1,047	157	1 612
1906	4,376	13,890	3 175	1,047	240	3 415
Totals	180,911	$295,513	—	$10,470	—	—
Averages	18,091	29,551	$1 624	1,047	$0 058	$1 682

The details of cost per ton for the calendar years 1905, 1906 and 1907 differ somewhat from those given in the previous table for the fiscal years and are as follows:

Table No. 13.

ITEMS.	1905.	1906.	1907.
Output for calendar years (tons)	5,600	5,337	1,117
Interest and depreciation ($1,047)	$0 187	$0 196	$0 938
Rental (royalty)	—	—	—
Quarrying	402	223	294
Labor	1 062	2 132	4 427
Teams	096	253	839
Coal, oil and light	052	088	105
Repairs	036	064	088
Sundry items	031	—	022
Totals	$1 866	$2 956	$6 713

It will be noted from the Tables 12 and 13 that for many years the cost of the crushed stone produced by this plant has been grossly excessive. It should long since have been relegated to the scrap pile or otherwise disposed of. But even in its dilapidated condition it is difficult to understand how the work done by it should have been so excessively costly if it had been managed honestly and well.

During the year 1906 the labor charges against this plant (including teams) amounted to $12,732. These charges alone amount to $2.38 per ton of crushed stone produced.

THE GROVE STREET CRUSHER.

This crusher is located at the corner of Grove and Centre streets, West Roxbury.

Thomas A. Welch, the owner of the land, had a crusher upon the property previous to the erection of the city plant, and it is still there. The city had purchased crushed stone from him before the erection of its own plant. Under a contract dated April 27, 1901, he was to furnish the city with

crushed stone at 90 cents per ton at the crusher. Under a contract dated October 2, 1906, the city agreed to purchase crushed stone from Welch (no quantity named) at a price of $1.25 per ton, delivered in a pile at the crusher, although it is of record that the city had been in numerous cases, about the same time, buying crushed stone, delivered on the streets where needed, at the same price — $1.25 per ton. The city supplied a weigher to weigh the stone. According to the report of 1906, the city thus bought from Welch during that year 5,384 tons of stone.

On April 2, 1907, a contract was entered into between the city and Welch, under which the city agreed to erect a crusher on Welch's lot, to be operated by Welch. The city agreed to supply a weigher to weigh the stone, and to pay Welch $1.25 per ton for all the crushed stone supplied, and also to pay him 70 cents per ton for all stripping removed. This contract is a very peculiar and interesting one and will be referred to again.

The machinery for this plant (erected early in 1907) was mostly brought from the old crusher at Kenney ledge and was, therefore, second-hand. Its estimated capacity is 200 tons per day.

There are two 15-inch by 9-inch Farrell crushers, one 11-inch by 16-inch and one 9-inch by 14-inch engine, one 48-inch by 17-inch locomotive boiler, and the necessary accessories to complete the outfit.

Mr. Cole estimates the present value of this plant at $7,140, and as it has been only recently erected its cost should not have exceeded $7,500. The city ledger gives the cost of the plant to November 1, 1907, as $4,839, but this evidently covers only the cost of moving the machinery from Kenney ledge and not the value of the machinery thus moved, which, according to Mr. Cole, was $1,470, making the total cost $6,309. Some of the bills for the erection of the plant had possibly not been posted when the books were examined about November 1, 1907.

The crusher was, after completion, operated by Welch in accordance with his contract with the city, except as noted further on. The quantity of crushed stone turned out and

paid for by the city up to January 1, 1908, was 9,399 tons, for which the city paid Welch at the rate of $1.25 per ton.

But in addition to thus paying for the stone the books show that the city expended for the operation of the present plant during the year $5,239.37, classified as follows:

To Welch, for stripping, as per contract	$3,297 06
City labor	888 64
Teams	151 75
Coal, oil and light	387 77
Repairs	484 66
Sundries	29 49
Total	$5,239 37

This amounts to 55 cents per ton for the stone supplied, which, added to the contract price of $1.25, made the cost to the city for crushed stone at the crusher $1.80 per ton.

Some items in the above account excite curiosity and comment.

The number of tons of strippings paid for was 4,710, or more than half as much as the crushed stone turned out. The 70 cents per ton paid for this stripping was doubtless about three times what it cost. As this was the first year's work of the crusher, and as the ledge had been already opened, the agents of the city must have known that the percentage of stripping would be very large, and should have insisted upon a more reasonable price for this part of the work.

The charge for labor was doubtless (partly at least) for weighers, which the city agreed to furnish, and the charge for teaming was probably for shifting stone from bins to piles, which the city had agreed to pay for. The $387.77 paid for coal, oil and light appears to have been simply a gift to Welch, for there is nothing in the contract requiring the city to furnish these supplies; on the contrary, while they are not named at all, the inference is undoubtedly warranted that they are to be furnished and paid for by Welch. Nor is anything said in the contract as to which party shall keep the plant in repair, though the city shouldered the burden. It is hard to understand why a plant should require nearly $500 for repairs within a few months after its erection.

A copy of the contract entered into between the city and

Welch is attached to this report, marked Appendix A. It is worthy of attention not only for its indefiniteness and inadequacy, but as a fair sample of the many contracts the city has made in the stone-crushing business.

Some of the notable features and delinquencies of this contract are the following:

(1.) Article 1 states that the property leased is shown by an attached plan. The attached plan, when examined, was found to give no boundaries or dimensions of the tract, and it is not possible for any one to determine from it what property the contract covers.

(2.) Article 3 provides that the city shall erect a crusher to be operated by the contractor. But there is nowhere any stipulation that the contractor shall properly care for the machinery, and it is not stated which party shall pay for repairs and maintenance.

(3.) Article 5 is very ambiguously worded; literally, it seems to provide that all the stone delivered shall be paid for again and again on the first of each month. In any event it is not clear whether the payment on the first of each month is to be for the stone delivered during the month immediately preceding or the month preceding that one. Presumably the latter is meant, as the accounts for one month could hardly be gotten ready for payment through the regular channels on the first day of the next.

(4.) In Article 6 it is provided that the contractor shall be paid at the rate of $1.25 per ton for all the stone crushed and 70 cents per ton for all strippings removed, also he is to be paid at the established rates for teams employed to remove and store on the premises the crushed stone from the bins after the latter are filled. This, of course, relates to the surplus which the bins would not hold, but it is not clear that the contractor might not under this clause transfer all the stone from the bins to piles, thus charging teaming for the whole product.

(5.) It is nowhere stipulated that the crusher shall be used exclusively for crushing stone for the city; though it may be assumed that Welch would not be permitted to use it for supplying other customers.

(6.) Article 8, however, is the redeeming feature of the contract, since it provides that the city may instantly cancel it at any time, and may then have a reasonable time in which to remove its property.

As a business transaction the remarkable feature of this contract is that although, during the preceding year, Welch supplied the city with a large quantity of crushed stone for $1.25 per ton delivered at the crusher, he quarrying the rock, excavating and disposing of the stripping, crushing the rock with his own plant, and doing the required teaming for storage, all at his own expense, the city now agrees:

First. To furnish and build a crushing plant on Welch's lot at its own expense.

Second. To turn this plant over to Welch to be operated by him, and to pay him $1.25 per ton (the same price as was paid before) for all the crushed stone produced.

Third. To pay Welch 70 cents per ton for all the stripping required; and

Fourth. To allow him established rates for teams that may be required to handle stone from the bins to storage piles.

It would be interesting to know what induced the Street Department to make such a contract.

THE ROSSETER STREET CRUSHER.

Located between Geneva avenue and Rosseter street, Dorchester.

A crushing plant was built upon this lot in 1891 and 1892. The cost as shown by the books was about $5,300, but this is probably not correct. In 1900 it was declared unfit for use and of no value. It remained in service, however, until 1903, when it was burned down.

The original crusher here was of the gyratory type, but no record can be found of the disposal of this crusher, and it seems to have disappeared, as the city now has no crusher of this type.

The present plant was built in 1903–04, the old machinery being used as far as possible, but the engine was brought from the Codman street plant. The ledge is not now operated

because of legal complications, but the plant is occasionally used to crush rock brought from the streets, such as old curb and paving blocks, boulders, etc.

This lot is leased by the city from W. J. Emerson, under royalty contracts dated as follows:

William J. Emerson, October 10, 1891 . . .	10 cents per ton.
William J. Emerson, March 12, 1895	25 cents per ton.
William J. Emerson, February 1, 1896 . . .	25 cents per ton.
William J. Emerson, April 1, 1898	25 cents per ton.
William J. Emerson, July 14, 1902	18 cents per ton.

This last lease was extended to February 1, 1906. In addition to the above royalties on the rock taken out the city has paid a rental of $40 per month since January 1, 1904.

Description.

The plant is now in very poor condition. There are two crushers, 9-inch by 15-inch, but one of them is practically worn out. The engine is a 30-horse power "Atlas" and the boiler is of the locomotive type. The storage capacity of the bins is about 700 tons.

The city ledger shows the cost of the plant erected in 1903–1904 to have been $19,263, but this does not include the cost of the machinery on hand or that moved from other plants. There is no way of getting at the value of this accurately, but from Mr. Cole's inventory it may be assumed to be not less than $2,000 and the total cost which the city books should show should, therefore, be $21,263. Mr. Cole estimated the first cost of this plant as $17,562 and its present value at $9,079. The fact that the city is restrained by an injunction from working this ledge, and that the plant is, therefore, of little value in its present location, influenced Mr. Cole to place its present value quite low. Upon Mr. Cole's figures of cost and present value the total depreciation is about 50 per cent, but taking the city records of cost and Mr. Cole's present value the total depreciation is 57 per cent, or 19 per cent per year.

Operation.

The following contracts for quarrying and delivering stone to crusher are of record:

With James A. King, August 13, 1892	78 cents per ton.
With John McMorrow, June 10, 1894	75 cents per ton.
With P. F. Lonergan, September 13, 1897	70 cents per ton.
With James McGovern, August 25, 1902	70 cents per ton.
Extended to February 1, 1906	70 cents per ton.
(Contract terminated December 19, 1905.)	
With John F. Gill, December 20, 1905	70 cents per ton.

This contract is said to have been terminated early in January, 1906.

The number of days on which the plant is said to have been operated during the past three years was:

In 1905	68 days.
In 1906	41½ days.
In 1907	27 days.

As the cost of the old plant is uncertain, interest and depreciation charges cannot be figured previous to 1897. But according to the city records the output and cost of operation for the years 1897 to 1903, inclusive, were as follows:

Table No. 14.

YEAR.	Output, Tons of Crushed Stone.	COST OF OPERATION FROM CITY RECORDS.	
		Total.	Per Ton.
1897	22,717*	$35,847	$1 577
1898	27,392	17,424	636
1899	33,800	42,977	1 272
1900	17,073†	24,669	1 445
1901	4,234	15,722	3 714
1902	8,394	16,048	1 912
1903	2,078‡	11,317	5 446
Totals	115,688	$164,004	—
Averages	16,527	23,429	$1 417

* 3,902 tons Telford was also quarried and paid for.
† 734 tons Telford was also quarried and paid for.
‡ 688 tons Telford was also quarried and paid for.

In 1898, 4,000 tons were brought to the crusher from other sources, the cost of quarrying which was not included.

The records for the new plant show the following, and charges for interest and depreciation have been added, showing in the last column the total cost per ton:

Table No. 15.

YEAR.	Tons of Crushed Stone.	COST OF OPERATION FROM CITY RECORDS.		(COST, $21,263.) INTEREST, 4 PER CENT. DEPRECIATION, 19 PER CENT.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1904	26,800*	$41,568	$1 551	$4,890	$0 182	$1 733
1905	8,484	17,286	2 038	4,890	576	2 614
1906	2,062	9,995	4 846	4,890	2 372	7 218
Totals	37,346	$68,849	—	$14,670	—	—
Averages	12,448	22,950	$1 844	4,890	$0 393	$2 237

* 1,891 tons Telford also quarried.

The details for the calendar years 1905 and 1906 are as follows:

Table No. 16.

ITEMS.	1905.	1906.	1907.
Quantity of output for calendar year (tons)	7,935	3,155	944
Interest and depreciation ($4,890)	$0 616	$1 550	$5 181
Rental (royalty paid)	239	262	531
Quarrying	463	196	010
Labor	1 064	2 440	4 834
Teams	126	310	522
Coal, oil and light	076	094	282
Repairs	262	080	112
Sundry items	034	—	034
Totals	$2 880	$4 932	$11 506

The Rosseter street lot is used to a small extent as a city storage yard, and it is possible that a part of the excessive charges for 1906 and 1907 should have been charged to other

accounts. It will be noted that the output of crushed stone in 1906 was but 3,155 tons, and in 1907 was but 944 tons. Yet the ledger shows that the aggregate charges against this crusher for the two years were:

ITEMS.	1906.	1907.
Rental	$827 74	$501 25
Quarrying	617 06	9 64
Repairs	251 03	105 75
Labor	7,697 75	4,564 09
Teams	976 00	493 00
Coal, oil and light	297 50	266 69
Sundry items	—	32 23
Totals	$10,667 08	$5,972 65

Such charges are, in view of the quantity of stone turned out, preposterous, and can be explained only by erroneous accounts or by fraud.

If the crusher was operated for forty-one and one-half days in 1906, as the records show, the charge for labor is at the rate of $185 per day.

The charge for teams is . . . . . which is at the rate of $23.50 per day.	$976 00
Per ton crushed	91
The charge for coal, oil and light was	297 50

The actual cost of oil and lights for the short period of operation must have been very small. If we figure the coal at $4 per ton, at least seventy tons must have been used, which is double what should have been required. The same remarks apply to the operation for 1907.

OTHER CRUSHER PLANTS.

The crusher plants described in the preceding pages comprise all that are now in existence, but at least three other plants, now dismantled, but which were operated in recent years, seem to be worth attention.

THE MOSMAN LEDGE CRUSHER.

The lot situated on Montebello and Iffley roads, Roxbury, was leased from W. A. Mosman in 1900, and a crushing plant was erected there in the same year at a total cost, as shown by the city ledger, of $16,762. Most of the machinery for this plant was purchased new, as follows:

Crusher, 13 inches by 30 inches	$2,181 15
Extra parts	438 50
Elevator	657 00
Screen, complete, 36 inches by 13 inches	350 00
Chute	97 50
66-inch horizontal boiler	870 00
Smoke stack, 13 inches by 60 inches, and connections	285 00
80-horse power, 14 in. by 20 in., T. and H. automatic engine,	895 00
100-horse power heater	112 00
4½-inch by 2¾-inch by 4-inch pump	108 62
Tank	80 00
	$6,074 77

This list obviously embraces all the machinery of importance required or used, and the remainder of the cost, amounting to $10,687, must have been incurred for unimportant and inexpensive parts for the building material and for the cost of erecting the buildings and machinery. The machinery was supplied and erected for the city by B. F. Anthony & Son, and the buildings were presumably erected by the city by day work and not by contract. The bills submitted for the work by Anthony & Son are voluminous and in great detail, and it is now impossible to check and verify them, particularly as the plant is no longer in existence. Judging from the character of the plant the cost of erecting it must have been grossly excessive.

This plant after only three years' service was moved in 1903 to the Codman street ledge. The depreciation in value resulting from such removal must have been very great, but cannot be accurately determined. The buildings could not have been of much value for removal, and the foundations for the buildings and machinery were practically thrown away. It would be conservative to say that the value of the plant for removal did not exceed $8,000, making the depreciation $8,672, equal to a total depreciation of 52 per cent, or at the rate of 26 per cent per year for the two years only

during which the plant was operated, 1900 and 1901. According to the city books the output of the crusher for these two fiscal years and the cost of operation are shown below, the charges for interest and depreciation being added, as in other cases.

Table No. 17.

YEAR.	Output, Crushed Stone.	COST ACCORDING TO CITY BOOKS.		(COST, $16,762.) INTEREST, 4 PER CENT. DEPRECIATION, 26 PER CENT.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1900	33,132	$47,596	$1 436	$5,029	$0 152	$1 588
1901	37,565	73,600	1 959	5,029	134	2 093
Totals	70,697	$121,196	—	$10,038	—	—
Averages	35,348	60,598	—	5,029	$0 142	$1 857

Although there is no record of any crushed stone having been produced at this plant in 1902, there appears on the city books a charge of $3,565 for operating the plant in that year, of which $825.56 is for unposted charges for the preceding year, leaving as properly chargeable to 1902, $2,739.90, divided among the following items:

Coal	$22 10
Teams hired	220 50
Labor	2,497 30
Total	$2,739 90

As the plant was not operated at all during the year the only expense that should have been incurred was for watchmen, and this should not have exceeded $1,250 for the year.

THE KENNEY LEDGE CRUSHER.

This crusher plant belonged to the city and was erected on a lot leased from James W. Kenney. The first crusher seems to have been erected here in 1895 at a cost of $7,623, but this figure does not include the cost of machinery moved from other plants. In 1896 a part of the plant was moved to the Bleiler ledge. There is no record of how much was thus moved. The Superintendent of Streets in his report for 1896

states that he moved the crusher from the Kenney ledge to the Bleiler ledge because the rock at the former was then nearly exhausted and of poor quality. Yet a plant was moved back to the Kenney ledge in 1900. Between 1896 and 1898 there seems to have been various changes and removals of which no record can be found at the City Hall.

In 1898 the whole plant was removed to the Chestnut Hill avenue ledge, Brighton, where it still is. In 1900 the Bleiler street plant was moved to this Kenney ledge at a cost, according to the records, of $10,780. In 1907 this plant was again removed to the Grove street ledge, and no plant now exists at the Kenney ledge, though the city is still paying a rental of $200 per month for the property. The royalty paid to Kenney previous to June 8, 1900, was at the rate of 15 cents per ton, but since that date the royalty has been at the rate of 17 cents per ton, the last contract having been extended to February 1, 1908. The rate paid for quarrying and delivering the stone to the crusher has been, since 1902, 70 cents per ton, including both rock and stripping.

The output and cost of producing crushed stone at this crusher for the years 1900 to 1905, as shown by the city records, was as given below. With interest and depreciation (assumed at 10 per cent) added, the total cost per ton is shown in the last column. (The cost of the plant previous to 1900 is not known.)

Table No. 18.

Fiscal Year.	Output, Tons of Crushed Stone.	City Records, Cost.		(Cost, $10,780.) Interest, 4 Per Cent. Depreciation, 10 Per Cent.		Total Cost Per Ton.
		Total.	Per Ton.	Total.	Per Ton.	
1900	6,177	$9,472	$1 534	$1,509	$0 244	$1 778
1901	9,679	29,671	3 067	1,509	156	3 223
1902	25,021	34,674	1 385	1,509	060	1 445
1903	28,782	29,358	1 020	1,509	052	1 072
1904	10,825	32,455	2 998	1,509	139	3 137
1905	5,579	14,744	2 643	1,509	271	2 914
Total	86,063	$150,374	—	$9,054	—	—
Averages	14,344	25,062	$1 746	1,509	$0 105	$1 851

Continued Rental Paid for the Lot.

Although the rock was practically exhausted from this lot when the crusher was moved away in 1907, the city continues to pay a rental of $200 per month for the property.

The original lease or contract, entered into May 12, 1895, stipulated that the rock was to be removed over the whole lot to a certain grade, and this provision was retained in all subsequent renewals and extensions. It appears that in the quarrying work the rock was excavated to a considerable depth below the stipulated grade and was not filled in with waste material to bring it back up to that grade. The quantity of filling required to restore the lot to grade was said to be about 12,000 cubic yards.

A lease entered into June 7, 1902, expired on February 1, 1904. But on April 20 of that date the city had not removed the crusher property, though the ledge was exhausted. The negotiations for a further extension seem to have been at first verbal, but on June 20, 1906, the Superintendent of Streets wrote Mr. Kenney asking an extension of the lease until July 1, 1907, and requesting terms. The superintendent again wrote Kenney on June 20, 1907, saying that the price asked by Kenney ($3,600) per year was excessive, and suggesting that a fair price would be $1,500 per year. There seems to have been further negotiations, resulting in the signing of a new lease on September 5, 1906, which expired on February 1, 1908, the terms being that in addition to a royalty on any rock that might be taken out, the city was to pay Kenney a rental of $200 per month, beginning with the month of February, 1906. Presumably it was intended, in the meantime, to complete the filling required on the lot, though nothing is said in the lease about this. If the city fails to make the fill before the expiration of the present lease Kenney will doubtless still have a claim for damages or for further rental. The $2,400 that will be paid Kenney under the existing lease will be a clear loss to the city, which might have been obviated except for the carelessness of its agents.

Although there was no crushed stone produced at this crusher in the calendar year 1906, the city ledger shows the following expenditures for that year charged to this crusher:

Rental	$2,200
Repairs	79
Teams	270
Labor	3,511
Total	$6,060

It is possible that this expenditure (except the rental) was made in filling up the parts of the lot that are below grade, as explained above.

SAVIN HILL AVENUE CRUSHER.

A crusher was first built at the Savin Hill ledge in 1891, the machinery being moved from the Bird street plant.

The city accounts show that this crusher was maintained up to 1902. The ledgers contain charges against the crusher for the years 1897 to 1902, inclusive, as follows:

For 1897	$1,486 12
For 1898	757 37
For 1899	752 74
For 1900	552 19
For 1901	604 31
For 1902	60 00
Total	$4,212 73

Very little can be found in the records relating to the history or operation of this plant. It seems to have been operated by John McMorrow, who sold stone crushed at the plant to the city for $1.65 per ton delivered on the streets in South Boston and for $1.50 per ton for stone delivered in Dorchester. In addition to thus buying the output the city seems to have kept the plant in repair and to have paid for a weigher at the crusher. The sums named above were doubtless expended for these purposes.

The records show that the city paid McMorrow for stone thus supplied, as follows:

In 1897	$29,048
In 1898	19,344
In 1899	15,783
In 1900	8,438
In 1901	12,105
In 1902	900
Total	$85,618

The plant seems to have been practically worn out at the last named date and McMorrow sold it as junk, pocketing the proceeds. Practically the city seems to have donated the plant to McMorrow soon after it was erected, paying the expenses of maintenance and purchasing the product at prices much above the actual value of the material.

GENERAL DISCUSSION OF RESULTS.

Cost and Present Value of Crushers.

Table No. 1, page 7, gives in condensed form the aggregate cost of the eight crusher plants now in existence, as shown by the city books, the cost as estimated by Mr. Cole, and their present value (in October, 1907) as given by his (Mr. Cole's) inventory.

As previously stated the figures of cost obtained from the city books are incomplete and unreliable.

Mr. Cole's estimate of the original cost of each plant is doubtless substantially correct, but for the reasons previously given cannot be regarded as accurate. According to his estimate the aggregate cost of the eight crusher plants at the time of their erection was $132,731. This does not include the cost of the real estate where the lots are owned by the city.

The date of purchase, cost and present assessed valuation of this real estate is as follows:

DESIGNATION.	Date of Purchase.	Price Paid.	Assessed Valuation 1907.
The Chestnut Hill avenue property	1882	$30,000	$79,800
The Codman street property	1870	5,988	15,000
The Codman street property	1907	13,370	5,200
The Dimock street property	before 1870	not known	67,500
Total	—	—	$167,500

It appears from this that the real estate owned by the city at these three plants is worth about two and a half times the present value of all the machinery and buildings at all these plants.

The cost and value of this real estate has not been taken into consideration as capital invested in computing the cost of operation of the crushers. Its increase in value has undoubtedly been largely due to the natural enhancement in value of real estate in the city, but in some cases, at least, the value has been materially increased by the grading down of the lots due to quarrying and crushing operations. It is not possible, however, to arrive at any accurate conclusion in the matter and, therefore, it has been thought best to disregard this element in arriving at the cost of crushed stone. It would not, if taken into account, affect the results very materially.

According to Mr. Cole's inventory the fair present value of the eight crushing plants themselves considered as going concerns is $66,960. This is much more than the *market* value of the property. Should the city determine to sell all this plant, it is not likely that more than half the sum stated would be realized; $30,000 would probably be a liberal estimate of its present market value.

Character and Condition of Crusher Plant.

A large part of the machinery is old and almost worn out; much of it, particularly the crushers, is of antiquated design. Nearly all the crushers are of too small capacity for economical work. Not only is the cost of operating such small plants relatively high, but the rock must be broken into much smaller fragments in order that it may be fed into the machine, thus increasing the cost of quarrying. If the city is to continue in the stone-crushing business a great deal of the present plant should be discarded and replaced with new, modern machinery of the best design, having a capacity large enough to be operated with the greatest economy. The cost of the product could thus undoubtedly be materially reduced.

No modern private concern would undertake to produce

large quantities of crushed stone with such outfits as these city crushers with any expectation of making the business profitable.

The Frequent Moving of Crushers.

In attempting to trace the history of the city's stone-crushing business one is struck with the frequency with which the crushers have been moved from one location to another. Such removals are necessarily very expensive. The records show that the more recent moves have each cost from ten to fifteen thousand dollars. It is not possible now to learn the motives or reasons for many of these moves. The inference is warranted that they were not always brought about by sound business reasons, and if common rumor may be trusted some of the moves, at least, were influenced by personal or political motives.

Magnitude of the Business.

Table 19 is a condensed statement of the output of the various city crushers for each of the eleven years, 1897 to 1907, inclusive, also the total quantity produced by each crusher in that time. Some crushers not now in existence, but which were operated during the period, are included to make the statistics more complete.

It will be noted that the annual product varied from a minimum of 41,773 tons in 1907 to a maximum of 241,411 tons in 1905, the total product for the ten years being 1,625,831 tons, and the average 147,803 tons per year. This is an enormous quantity of crushed stone to be used by the city. Some idea of its magnitude may be realized when it is stated that the average yearly production was sufficient to build over 40 miles of macadam road 24 feet wide, the stone being 6 inches deep.

The object of the very large production of crushed stone in 1905 is not evident, since about 126,000 tons remained on hand January 1, 1906.

Quality of the Crushed Stone Produced.

The crushed stone produced by the city seems to be generally good and suitable for road building and structural work.

This was not, however, invariably true. At several times during the autumn of 1907, when the Columbia crusher was visited, the rock fed to the crushers was of poor quality and contained large quantities of earth and waste. In a number of the cart loads dumped into the crushers more than one-half the whole was earth and waste. While the greater part of this earth was subsequently removed by the screens, a large quantity adhered to the fragments of stone and went into the bins and storage piles. In the large storage pile at the yard there was a stratum about a foot thick where the voids in the stone were filled with earth or rock dust, it having been washed off of the upper portion of the stone in the pile and deposited at a distance from the surface. This material was unfit for road making or structural work. The object of running such material through the crusher was stated to be to separate the rock which it contained from the mass of gravel and earth.

Table No. 19.

Product of Stone Crushers in Tons of 2,000 Pounds for the Ten Years 1897--1906, Inclusive, from the Annual Reports of the Street Department.

Name of Crusher.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.†
Bleiler street	26,636*	16,221*	37,523*	2,521	—	--	—	24,658	33,935	1,950	104
Centre street	20,052	31,510	15,585	17,027	7,683	9,688	32,428	29,345	48,593	13,765	1,099
Chestnut Hill avenue	18,869	1,473	788	4,616	18,597	19 655	43,028	23,976	23,575	3,012	9,056
Codman street	18,498*	16,127	11,163	13,975	10,519*	32,437*	42,733*	19,911	50,140	1,043	1,004
Commonwealth avenue ledge	2,547	8,526*	41,256*	8,283	—	—	—	—	—	—	—
Dimock street	37,265	16,362	22,088	26,204	17,697	22,668	5,103	22,461	6,687	4,376	1,117
Kenney	2,988	—	—	6,177	9,679	25,021	28,782	10,825	5,579	—	—
Rosseter street	22,717*	27,392	33,800	17,073*	4,234	8,394	2,078*	26,800*	8,484	2,062	944
Mosman	—	—	—	33,132	37,565	—	—	—	—	—	—
Columbia road	—	—	—	—	23,992	50,627*	68,854*	31,269*	54,418	31,981	19,050
Grove street	—	—	—	—	—	—	—	—	—	5,384	9,399
Totals	149,572	117,611	162,203	128,990	129,966	178,490	223,006	189,245	241,411	63,564	41,773

Total production for ten years equals 1,625,831 tons.

* In these years more or less Telford stone was also taken out from these ledges.

† Calendar year.

Cost of Production.

Table No. 20 gives the total amounts, as shown by the city ledgers, chargeable to the operation and maintenance of the stone crushers for each of the ten fiscal years, 1897 to 1906, inclusive. These do not include charges for interest and depreciation. It will be observed that the minimum expenditure for any one year was $131,875 for 1898, and the maximum was $352,848 for 1904. The total sum expended in the ten years was $2,348,540, an average of $234,854 per year. The table gives the expenditures at all the crushers operated in the ten years, including some not now in existence. Dividing the total expenditure by the total output for the ten years gives an average cost of very nearly $1,483 per ton (exclusive of interest and depreciation) for the whole period. Interest and depreciation for this whole period cannot be determined accurately, but it was approximately 12 cents per ton, making the average total cost to the city $1.60. This figure seems to be confirmed by the practice of the Street Department in charging out crushed stone to all construction work at that price.

Table No. 20.

Table Showing Total Costs of Producing Crushed Stone at the Several Crushers for the Ten Fiscal Years 1897–1906, Inclusive.

(The figures are taken from the books of the Street Department.)

Name of Crusher.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Bleiler	$35,956	$30,037	$48,723	$18,818	—	—	—	$37,274	$43,807	$12,160
Centre street	35,206	30,023	32,587	36,477	$12,912	$42,393	$33,530	58,163	58,727	31,474
Chestnut Hill avenue	23,818	4,485	1,240	5,758	31,547	29,126	31,889	40,452	35,615	8,537
Codman street	27,713	13,601	15,704	17,232	19,942	53,536	44,284	45,771	50,979	14,200
Commonwealth avenue	7,597	2,533	1,223	1,344	—	—	—	—	—	—
Dimock street	52,430	32,991	25,432	37,704	25,065	46,306	22,056	29,911	9,728	13,890
Kenney	7,068	24	—	9,472	29,671	34,674	29,358	32,455	14,744	5,716
Rosseter street	35,847	17,424	42,977	24,669	15,722	16,048	11,317	41,568	17,286	9,995
Mosman	—	—	—	47,596	73,600	3,565	—	—	—	—
Columbia road	—	—	—	—	29,382	78,974	82,332	67,254	68,728	74,956
Savin Hill avenue	1,468	757	753	552	604	60	—	—	—	—
Totals	$227,121	$131,875	$168,639	$199,622	$238,445	$304,682	$254,766	$352,848	$299,614	$170,928

Note.—The sum of $4,660 charged to "East Boston's Crushers" and the sum of $5,726 damages paid on account of the "Tremont Street Crusher" back in 1898 are not included in the above.

The cost in the different years varies considerably as follows (excluding interest and depreciation):

Cost in 1897	$1 52
Cost in 1898	1 12
Cost in 1899	1 08
Cost in 1900	1 55
Cost in 1901	1 83
Cost in 1902	1 71
Cost in 1903	1 14
Cost in 1904	1 86
Cost in 1905	1 24
Cost of 1906	2 69

The cause of these wide differences in cost cannot be ascertained from the records available, particularly for the earlier years.

Cost of Producing Crushed Stone in the Years 1905, 1906 and 1907.

It has not been attempted to analyze the operation of the crushers for the years 1897 to 1904, inclusive.

A more careful study was attempted of the management of the crushers and of the cost of producing crushed stone at each for the calendar years 1905, 1906 and 1907, and the principal results for each individual crusher have already been given.

The various items that make up the total cost per ton of crushed stone produced for each of the three years are brought together in Tables Nos. 21, 22 and 23. The bottom line of each table shows the average cost at all the crushers for that year.

It will be observed that there is a wide variation in the unit cost of the same item at the various crushers in each year, and the variation between the same items for the three years is especially noticeable. The item for interest and depreciation varies, of course, inversely as the quantity of stone crushed. The items for royalty and for quarrying should be determinable from the contract prices paid for those services, though they do not always seem to be so. The items for labor and for teams show surprising differences, particularly when those for 1905 are compared with those for 1907.

It has been previously stated that in many cases the charges for labor and teams were out of all proportion to the work done. It is mostly because of these extraordinary charges that the average cost per ton of crushing stone in 1907 was more than double that in 1905.

Table No. 21.

Details of Cost of Producing Crushed Stone, Calendar Year 1905.

NAME OF CRUSHER.	Output, Tons.	Interest and Depreciation.	Rental.	Quarrying.	Labor.	Teams.*	Coal, Oil and Light.	Repairs.	Sundry Items.	Total.
Bleiler	33,579	$0 144	$0 192	$0 987	$0 178	—	$0 030	$0 024	—	$1 555
Centre street	47,969	027	161	927	160	—	030	059	—	1 364
Chestnut Hill avenue	32,864	055	—	801	132	$0 068	043	040	$0 009	1 148
Codman street	47,129	113	—	904	144	034	035	039	018	1 287
Columbia road	54,195	093	105	908	232	029	034	066	012	1 479
Dimock street	5,600	187	—	402	1 062	096	052	036	031	1 866
Kenney	5,579	271	170	1 592	720	—	048	031	988	2 920
Rosseter street	7,935	616	239	463	1 064	126	076	262	034	2 880
Totals	234,851	—	—	—	—	—	—	—	—	—
Averages †	—	$0 110	$0 096	$0 896	$0 237	$0 030	$0 036	$0 055	$0 012	$1 472

* The charges for teams are for hauling the stone from the storage bins after these are filled and storing it in piles on the lot.

† These averages are not the arithmetic means of the columns above them; they are obtained by dividing the total charges to each item by the total production.

Table No. 22.

Details of Cost of Producing Crushed Stone, Calendar Year 1906.

Name of Crusher.	Output, Tons.	Interest and Depreciation.	Rental.	Quarrying.	Labor.	Teams.*	Coal, Oil and Light.	Repairs.	Sundry Items.	Total.
Bleiler	2,090	$2 309	$0 116	$0 213	$3 495	$0 198	$0 122	$0 084	$0 103	$6 640
Centre street	14,389	090	180	908	556	050	051	050	—	1 885
Chestnut Hill avenue	2,483	722	—	187	2 459	463	227	039	080	4 177
Codman street	2,874	1 855	—	341	2 835	182	063	065	—	5 341
Columbia road	32,561	154	154	1 328	461	066	053	021	026	2 263
Dimock street	5,337	196	—	223	2 132	253	088	064	—	2 956
Rosseter street	3,155	1 550	262	196	2 440	310	094	080	—	4 932
Total	62,889	—	—	—	—	—	—	—	—	—
Averages †	—	$0 409	$0 173	$0 952	$1 068	$0 121	$0 065	$0 044	$0 020	$2 852

* The charges for teams are for hauling the stone from the storage bins after they are filled and storing it in piles on the lot.

† These averages are not the arithmetic means of the columns above them; they are obtained by dividing the total charges to each item by the total production.

Table No. 23.

Details of Cost of Producing Crushed Stone, Calendar Year 1907.

NAME OF CRUSHER.	Output, Tons.	Interest and Depreciation.	Rental.	Quarrying.	Labor.	Teams.*	Coal, Oil and Light.	Repairs.	Sundry Items.	Total Per Ton.
Bleiler	104	$46 54	$0 35	—	$36 34	$0 07	$1 21	$2 63	$0 60	$87 74
Centre street	1,099	1 17	18	$0 70	4 66	13	67	1 04	02	8 57
Chestnut Hill avenue	9,056	20	—	54	43	08	13	07	—	1 45
Codman street	1,004	5 31	—	04	2 71	12	26	10	02	8 56
Columbia road	19,050	26	12	1 08	62	09	06	09	10	2 42
Dimock street	1,117	94	—	29	4 43	84	10	09	02	6 71
Rosseter street	944	5 18	53	01	4 84	52	28	11	04	11 51
Total	32,374	—	—	—	—	—	—	—	—	—
Averages †	—	$0 747	$0 097	$0 823	$1 135	$0 129	$0 117	$0 129	$0 062	$3 24

* The charges for teams are for hauling the stone from the storage bins after they are filled and storing it in piles on the lot.

† These averages are not the arithmetic means of the columns above them; they are obtained by dividing the total charges to each item by the total production.

It will be observed that in nearly all the cases where the labor and team charges are exorbitant the output of the crusher was very small. It was at first thought that these excessive charges might result from the failure to post some of the charges for the preceding year in the accounts of that year and in carrying them over and posting them with the accounts of the succeeding year. A pretty careful investigation showed, however, that this had not been done.

A partial explanation may be found in the fact that a part of the city's regular crusher force is continued in service whether the crushers are running or not. Such a practice would be entirely proper where the shut-downs were of short duration and the crusher was kept in operation during the greater part of the year. It would, however, be entirely unwarrantable where the plant was operated but a few days out of the whole year, as was true of several of the crushers. But even if the regular operating force were kept on full pay during the whole year it would not account for the enormous charges in a number of cases.

The extraordinary charges for labor and teams at most of the crushers in 1906 and 1907, with the small output of crushed stone, suggested a further inquiry into the matter, and an effort was made to trace the labor account for 1906 at three of the crushers — the Bleiler, the Codman and the Kenney — back to the original entries in the time books. The results are shown in Tables 24, 25 and 26. The most notable fact disclosed by these tables is that the excessive charges for labor occur largely in the four months — January, February, March and December. These are the four months of the year when construction and repair work on the streets is practically suspended and no crushed stone is needed or used, and when, therefore, it might be expected that the crushers would not be operated at all. We naturally inquire why this condition of affairs should occur, and a careful examination leads to the conclusion that these crusher plants were habitually used as a retreat for such city employees as it was desired to carry on the pay rolls of the city during the winter months when they could not be employed upon the streets. It was found that this conclusion was verified

by the actual records of the department. General orders seem to have been given to send this class of employees to the crusher plants at the close of the season's work on the streets. Some of these orders were found upon record. The following letter is an instance: (See department letter book, June, 1897, to February, 1898, page 847.)

Table No. 24. — Bleiler Crusher.

Distribution of Labor and Output, Calendar Year 1906.

Classification.	Rate.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Sub-foreman.....	$3 50	$87 50	$119 00	$140 00	—	—	—	—	—	—	—	—	$42 00	$388 50
Engineer.....	3 00	96 00	78 00	87 00	$80 50	$101 50	—	—	—	—	—	—	59 50	502 50
Fireman.....	2 83	93 50	104 83	87 83	34 00	—	—	—	—	—	—	—	65 18	385 34
Sub-foreman.....	2 50	—	—	—	—	—	—	—	—	—	—	—	30 00	30 00
Weigher.....	2 50	65 00	57 50	72 50	57 50	72 50	$57 50	$59 00	$66 00	$63 25	$66 00	$79 75	63 25	779 75
Powderman.....	3 00	34 50	51 00	42 00	—	—	—	—	—	—	—	—	36 00	163 50
Steam driller.....	2 50	32 50	—	—	—	—	15 00	57 50	45 00	—	—	—	—	150 00
Steam driller.....	2 25	63 00	40 50	40 50	—	—	—	—	—	—	—	—	24 75	168 75
Janitor.....	2 50	45 00	57 50	57 50	—	—	—	—	—	—	—	—	—	160 00
Watchman.....	2 25	110 25	166 50	198 00	151 88	229 50	182 25	132 75	141 75	121 50	126 00	139 50	130 50	1,830 38
Powderman.....	2 25	6 75	—	—	—	—	—	—	—	—	—	—	—	6 75
Labor.....	2 19	21 90	28 47	37 23	—	—	—	—	—	—	—	—	—	87 60
Labor.....	2 10	6 30	—	—	—	—	—	—	—	—	—	—	—	6 30
Labor.....	2 00	516 00	842 00	710 00	—	—	—	—	—	—	—	—	326 50	2,394 50
Watching.....	2 00	36 00	10 00	24 00	—	—	—	42 00	70 00	54 00	56 00	80 00	54 00	426 00
Totals.....	—	$1,214 20	$1,555 30	$1,496 56	$323 88	$403 50	$254 75	$291 25	$322 75	$238 75	$248 00	$299 25	$831 68	$7,479 87
Output of crusher, tons ...		496	307	910	—	—	—	—	—	—	—	—	609	—

The above table showing the distribution of labor does not include legal holidays, but does include half-holidays. Neither legal nor half-holidays are charged against the crusher, but are paid for by special dispensation.

The months as designated are not exact calendar months, but correspond with dates of the time books. January, 1906, accounts include dates of December 29 and 30, 1905.

The output by months is strictly comparable with the labor charges for the same period.

Table No. 25.—Codman Crusher.

Distribution of Labor and Output, Calendar Year 1906.

CLASSIFICATION.	Rate.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Assistant foreman,	$4 00	—	—	—	$44 00	$116 00	$92 00	$20 00	—	—	—	—	—	$272 00
Sub-foreman.....	3 50	$192 50	$259 00	$304 50	35 00	49 00	21 00	—	—	—	—	—	$35 00	896 00
Sub-foreman.....	3 00	—	—	—	—	—	—	—	—	—	—	—	12 00	12 00
Engineer.....	3 50	56 00	87 50	105 00	77 00	101 50	80 50	80 50	$63 00	$42 00	$7 00	$56 00	80 50	836 50
Fireman.....	2 83	73 66	65 17	85 00	65 17	82 16	65 17	65 17	51 00	5 67	—	—	17 00	575 17
Weigher.....	2 75	68 75	63 25	82 50	63 25	79 75	63 25	64 63	82 50	63 25	66 00	79 75	63 25	840 13
Tallyman.....	2 00	50 00	46 00	50 00	34 00	58 00	*47 50	51 75	67 50	51 75	54 00	65 25	51 75	627 50
Watchman.....	2 25	51 75	39 75	33 75	11 25	6 75	—	—	—	—	—	—	13 50	156 75
Watchman.....	2 00	10 00	—	—	—	—	—	—	—	—	—	—	—	10 00
Powderman.....	2 25	13 50	39 75	33 75	11 25	—	—	—	—	—	—	—	—	98 25
Labor.....	3 00	108 00	180 00	180 00	—	—	—	—	—	—	—	—	36 00	504 00
Labor.....	2 50	57 50	82 50	157 50	—	—	—	—	—	—	—	—	15 00	312 50
Labor.....	2 25	20 25	74 25	77 63	11 25	6 75	—	—	—	—	—	—	13 50	203 63
Labor.....	2 10	67 20	113 40	147 00	—	—	—	—	—	—	—	—	16 80	344 40
Labor.....	2 00	528 00	779 00	1,023 00	100 00	70 00	60 00	—	—	—	—	—	76 00	2,636 00
Boy.....	1 50	—	—	—	—	—	—	27 00	45 00	34 50	36 00	—	—	142 50
Totals.....	—	$1,297 11	$1,829 57	$2,279 63	$452 17	$569 91	$429 42	$309 05	$309 00	$197 17	$163 00	$201 00	$430 30	$8,467 33
Output of crusher, tons...		1,881	784	502	—	—	—	—	—	—	—	—	—	—

* From June to December rate increased to $2.25 per day.

The above table showing the distribution of labor does not include legal holidays, but does include half-holidays. Neither legal nor half-holidays are charged against the crusher, but are paid for by special dispensation.

The months as designated are not exact calendar months, but correspond with dates of the time books. January, 1906, accounts include dates of December 29 and 30, 1905.

The output by months is strictly comparable with the labor charges for the same period.

Table No. 26. — Kenney Crusher.

Distribution of Labor and Output, Calendar Year 1906.

Classification.	Rate.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Weigher.....	$2 75	—	—	—	—	—	—	—	$16 50	—	—	—	—	$16 50
Messenger.....	2 50	$60 00	$57 50	$57 50	$30 00	$15 00	$42 50	$57 50	60 00	$57 50	$60 00	$72 50	$65 00	635 00
Watching.....	2 25	63 00	60 75	76 50	103 50	153 00	96 75	110 25	157 50	121 50	126 00	153 00	121 50	1,343 25
Watching.....	2 00	112 00	108 00	136 00	68 00	68 00	54 00	54 00	70 00	56 00	56 00	68 00	56 00	906 00
Totals.....	—	$235 00	$226 25	$270 00	$201 50	$236 00	$193 25	$221 75	$304 00	$235 00	$242 00	$293 50	$242 50	$2,900 75
Filling.														
Sub-foreman.....	$3 00	—	—	—	—	—	—	$54 00	$90 00	—	—	—	—	$144 00
Labor.....	2 10	—	—	—	—	—	—	35 70	50 40	—	—	—	—	86 10
Labor.....	2 00	—	—	—	—	—	—	132 00	218 00	—	—	—	—	350 00
Totals.....	—	—	—	—	—	—	—	$221 70	$358 40	—	—	—	—	$580 10

This plant was not operated during 1906.

The above table showing the distribution of labor does not include legal holidays, but does include half-holidays. Neither legal nor half-holidays are charged against the crusher, but are paid for by special dispensation.

The months as designated are not exact calendar months, but correspond with dates of the time books. January, 1906, accounts include dates of December 29 and 30, 1905.

January 8, 1898.

MR. F. M. MCCARTHY,
Foreman, District No. 4.

DEAR SIR,— I want you to put every available man into the crushers so we can keep the expenses down on the maintenance, so these men can be charged up to the streets on which the crushed stone will be used in the spring.

Yours truly,
(Signed) J. L. KELLY,
Deputy Superintendent Paving Division.

Identical letters were sent to Foremen Shea, Langhan and Hayden.

Such a disposition of the employees might have been entirely proper if their services were needed or could have been profitably employed at the crushers during the winter months. The records show clearly that they were not less profitably employed, or rather that the great majority of them were not employed at all.

Thus, at the Bleiler crusher, the pay roll charges and the output of crushed stone for the four winter months were as follows:

	Pay Roll.	Output, Tons.
January, 1906	$1,214 20	496
February, 1906	1,555 30	307
March, 1906	1,496 56	910
December, 1906	831 68	609

A similar condition of affairs will be observed at the Codman crusher, except that in December, 1906, while the pay roll charges amounted to $430.30, no crushed stone whatever was turned out.

As the tables show, these pay roll charges include the payments to the engineer, firemen, weighers, etc., who seem to have been kept employed whether the crushers were operated or not. Thus, the Bleiler crusher was not operated at all during the months of April, May, June, July, August, September, October and November, during which months the pay roll shows a total payment to these classes of men of $2,382.13.

Similarly, at the Codman crusher the payments for the same months (when the plant was not operated) amounted to $2,630.72.

At the Kenney crusher, where the plant was not operated at all during the whole year, a weigher, a messenger and two watchmen were employed throughout the year at a total cost of $2,900.75. It is true that some work was done during the year in filling the over-deep excavation at this ledge, but this work certainly did not require the services of a weigher or a "messenger."

It may be claimed that the presence of the weigher was necessary to weigh the stone sent to the streets from the stored piles at the crushers. The quantities sent out from these three crushers during the whole year were as follows:

From the Bleiler crusher	3,807 tons.
From the Codman crusher	14,353 tons.
From the Kenney crusher	9,499 tons.

This was doubtless sent out during the summer months, and as the amount paid the weigher at the Codman crusher during these eight summer months was $562.38, the cost of weighing was nearly 4 cents per ton, while, figuring in the same way, the cost of weighing at the Bleiler crusher was 13½ cents per ton, an inexcusable amount in either case for the service.

Contract Prices for Quarrying.

It seems singular that the prices paid for quarrying rock and delivering it to the crushers should be substantially the same, regardless, apparently, of differences in the actual cost of doing the work. The cost of excavating and disposing of stripping (earth) is only about one-quarter or one-fifth of the cost of quarrying rock, and the relative quantities of each is, therefore, an element to be taken into account when contracting for the combined work. But this consideration seems to have been ignored. Thus the contract price at the Columbia road crusher has been uniformly since 1902, 70 cents per ton, although the percentage of stripping under the different contracts has varied, as follows:

Contract with H. P. Nawn	6.6 per cent.
Contract with George J. Regan	15.6 per cent.
Contract with D. F. O'Donnell	45.4 per cent.
Contract with James A. Mahan	34.5 per cent.

Similar conditions have apparently prevailed at the other crushers, but the exact relative quantities of rock and stripping have not been obtained.

Rental or Royalty Paid for Rock.

While the royalty paid per ton for the privilege of quarrying rock has varied within rather wide limits without any apparent justification, the average royalty paid has been in the neighborhood of 12 cents per ton. This has not usually yielded the owner an extravagant return upon the value of the property, considered as a simple rental. But in a number of cases certainly, and in most cases probably, the value of the property has been materially increased by the grading down of the lots due to the city's operations. One is unable to say that it would have been possible to make better terms with the owners, but in many cases, at least, it would have been better for the city to have purchased the property outright, thus itself getting the benefit of the enhancement in value due to the grading.

Extra Parts for Crushers.

One of the things which excites comment in Mr. Cole's detailed inventory is the number of new parts found on hand at the several plants for the repair of the crushers. At the eight crushers were found, in all:

84 New Jaw-plates, valued at	$5,936
144 New Toggle-plates, valued at	2,958
69 New Cheek-plates, valued at	1,378
Total value	$10,272

While it is necessary, or at least prudent, to keep on hand a few extra parts to quickly replace those that may be broken, there could be no possible necessity for keeping on hand such a stock as given above, at a cost to the city of over $10,000. Such parts are always kept in stock by the makers of the crushers, and could probably be procured within forty-eight hours after an order was placed for them. Many of the crushers owned by the city are of the same size and pattern, so that a comparatively small stock of extra parts would have

been sufficient to meet the emergencies of breakage. Evidences of wearing out could always have been discovered in time to order new parts for replacement when the machines were not running. If it were possible now to find out what was the motive for the purchase of this enormous stock of extra parts it might be very interesting. A large part of these extra parts were bought from the Taylor Iron and Steel Company in 1903.

Insurance.

No insurance is carried on the crushing plant except upon the boilers. All the boilers at the crushers and those on the road-rollers are insured for a lump sum of $60,000, — the premium paid being $500 for three years. This item is so small that it has not been considered in determining the cost of the crushed stone.

Supply and Market Value of Crushed Stone at Boston.

The City of Boston would be warranted in itself undertaking to produce the crushed stone needed for municipal work for one or more of the following reasons:

1. If crushed stone of suitable quality could not be purchased upon the open market.

2. If the city could not safely depend upon getting stone from outside sources in such quantities and at such rates of delivery as was demanded by a proper prosecution of the municipal work.

3. If the city could produce crushed stone at a lower cost than equally good material could be bought for upon the open market.

Other minor considerations may enter into the question, but the above are the controlling ones.

Consideration 1 requires no discussion, it being universally admitted that an abundance of rock of a quality equal in every respect to that crushed by the city can be obtained in Boston, or within a very reasonable distance of the city.

Regarding consideration 2: There being an abundance of rock in the vicinity of the city suitable for crushing, the

question of obtaining a sufficient supply for the needs of the city is one of crushing capacity, supplemented, if necessary, by adequate storage yards at convenient points within the city limits.

The average quantity of crushed stone produced per year by the City of Boston for the years 1897 to 1906, inclusive, has been 158,406 tons. The maximum quantity produced in any one of these years was 241,411 tons, but of this about 126,000 tons was not used that year.

It seems safe to assume that the city would not be likely to require for actual use more than 200,000 tons in any one year. There are plenty of single stone-crushing plants now in existence, some of them in the vicinity of Boston, capable of turning out more than this quantity per year. In fact, two rock crushers of a size now very common, and capable of doing the most economical work, would be sufficient to supply the whole quantity.

Under the project later outlined for adoption by the city there could be no reasonable doubt of an abundant supply at all times for the city's use.

I think it will hardly be questioned by any one at all familiar with the situation that an ample supply of crushed stone of the best quality could be procured by the city from outside sources.

Regarding consideration 3 there can be no doubt that all the crushed stone required by the city could be purchased at prices much below the cost of stone delivered from its own crushers.

Conclusive evidence on this point is afforded by the experience of the city in purchasing crushed stone from other parties during the year 1907. The Street Department bought crushed stone during that year, delivered on the streets where wanted, as follows:

From H. & D. Burnett, stone delivered at Franklin Park at $1.50 per ton.

From J. C. Coleman, stone delivered on streets at $1.50 per ton.

From Coleman Brothers, stone delivered on the streets at $1.40 per ton.

From H. P. Nawn, stone delivered on the streets at $1.50 per ton.

From the Tidewater Broken Stone Company, stone delivered on streets at $1.60 per ton.

The cost of delivering the stone from the crushers to the street is not known, but it probably averaged at least 40 cents per ton, so that the equivalent price at the crusher may have been from $1 to $1.20 per ton. The city bought crushed stone from J. C. Coleman during the year at $1 per ton, in the bins at his crusher.

The Boston Transit Commission bought crushed stone delivered along the line of the Washington Street Subway during the year 1907 from various parties at the uniform price of $1.50 per ton. A recent contract has been made by the commission with J. C. Coleman & Son under which the latter are to deliver crushed stone on the street at $1.40 per ton.

The Metropolitan Park Commission paid the following prices during the year 1907:

To H. & D. Burnett for crushed stone delivered on Revere Beach Reservation, $1.25 per ton. This delivery involved a haul by team of from three to four miles.

To Coleman Brothers (of Everett), $1.35 per ton for two-inch stone and $1.25 per ton for one-inch stone. The delivery involved a team haul of approximately two miles.

Numerous other cases could be cited to the same general effect, but those given are sufficient to show the prevailing market prices.

The prices paid by the Boston Transit Commission and by the Metropolitan Park Commission indicate that the prices for stone delivered at the crushers could not have exceeded $1 per ton.

My own knowledge and experience in the quarrying and crushing of rock of various kinds justifies the conclusion that the rock found in the vicinity of Boston, whether pudding-stone or trap-rock, can be quarried, crushed and sold from the bins at the crusher plant, at a good profit, for 75 cents to 80 cents per ton of 2,000 pounds.

The assumed conditions are that the stripping required is comparatively light, that the quarry has a workable face from 15 to 20 feet high, that the crushing plant is well designed and of large capacity, and that the cost of common labor is 20 cents per hour.

Inquiry among those engaged in the stone-crushing business in the vicinity of Boston confirms, in a measure, this estimate.

The Essex Trap Rock and Construction Company of Peabody, Mass., state that under a five years' contract to supply 100,000 tons per year they would probably make a price of $1 per ton, delivery to be f. o. b. cars at any Boston & Maine siding in Boston, Somerville or Cambridge.

The Massachusetts Broken Stone Company state that under a five years' contract they could agree to supply the City of Boston with crushed trap-rock, delivered on cars at any public siding in the city or vicinity, at a price of from $1.20 to $1.30 per ton, according to conditions and specifications.

John S. Lane & Son of Meriden, Conn., state that their usual price for crushed stone in considerable quantities, f. o. b cars at their plant, is 50 cents per net ton; that the present freight rate to Boston is 75 cents per ton, making the price f. o. b. cars at Boston $1.25 per ton. The distance from Meriden to Boston is 142 miles, yet this firm says that upon a contract for 500,000 tons they could probably name a price f. o. b. cars at Boston & Albany sidings in Boston somewhat below $1.25 per ton. The prices given above are named in written communications from the parties in my possession.

In view of all the facts I believe it perfectly safe to conclude that if the City of Boston should advertise for proposals to deliver all the crushed stone required for its municipal work, for a period of five years, the stone to be equal in quality to that now produced by the city, delivery to be on cars at convenient railroad sidings, or at designated points in the city, responsible bids would be received at prices not exceeding $1 per ton.

Should such a plan be adopted it would doubtless be advisable for the city to provide storage bins and yards at a few of the sidings where the largest quantities of stone were likely to be required, in order not only to reduce the cost of transferring

from cars to wagons, but to insure a supply against contingencies at the season when most stone would be used. Provisions of this character might add as much as 10 cents per ton to the cost of the stone, though five cents per ton would probably cover this item.

The cost of delivering the stone from cars and storage yards should not much, if any, exceed the cost of delivery from the present crusher plants, particularly if contracts based on competitive bids were made for such delivery.

I believe it is safe to figure that under the arrangement outlined the city would obtain all the crushed stone needed at a total cost not exceeding $1.10 per ton, loaded on wagons for hauling to the streets where needed.

Computed upon the total production and the total cost the average cost of the crushed stone produced by the city at its own crushers during the three years 1905, 1906 and 1907 was about $1.98 per ton at the crushers. If this material could have been purchased under contract for $1.10 the saving would have been 88 cents per ton, and the total saving on the three years' supply would have been, in round numbers, $290,500.

Assuming that the crushed stone produced during the eleven-year period, 1897 to 1907, inclusive, could have been bought under contract at the price of $1.10 per ton, the city has lost by the operation of its own crushing plants something like $870,000 in that period.

It may be claimed that the delivery of the stone at railroad sidings would involve a longer average haul than from the crusher sites, and that the crushers can be moved from place to place as required so as to reduce the haulage to a minimum. Without knowing definitely the location of future municipal work for which stone will be required it is not possible to determine whether or not this would be true. It is, however, very questionable whether any possible saving in haul compensates the city for moving a crusher at a cost of from $10,000 to $12,000 except in rare cases; and it is obvious from the above figures that even if the average haul were somewhat increased under the contract plan the saving would still be very large.

The cost of loading and unloading the stone into and out of wagons and of the delays incident thereto would be the same in either case, and the cost of hauling alone, at the present rates of wages, should not exceed 25 cents per ton per mile. Consequently, even if an additional average haul of one-half mile were necessary, the additional cost should not exceed 12½ cents per ton.

It is not unlikely that if the city were to offer its present crusher plant for sale it could be disposed of to local parties or contractors who would undertake to supply considerable quantities of crushed stone at quarries within the city at about the price estimated above.

In these estimates it has been my intention to keep on the safe side and I believe that my figures are conservative. The crucial test must, however, be the bids that would be submitted by responsible persons or corporations to supply the city with crushed stone.

The sound and business-like program for the city to follow would be to prepare full and careful specifications and form of contract, and then to ask public proposals to supply the city with all the stone it may need for a period of five years. When such proposals were opened the city would have a definite basis for action, and if the prices named were satisfactory a contract could be closed and action then taken to dispose of the city's crushing outfits.

RÉSUMÉ.

I have thought it more important to collect and arrange the facts relating to the city's stone-crushing business in such a way that they may be intelligently dealt with by the commission than to comment at length on these facts, or to suggest directions in which it might be profitable for the commission to push the inquiry further.

The facts disclosed and the conclusions that seem warranted may be briefly summarized, as follows:

1. While the Street Department has been engaged in the stone-crushing business for a long time, and upon a large scale,

there is evidence that the business has been carelessly and even recklessly conducted, and that as a consequence a very large sum of the city's money has been wasted.

2. The plant and machinery employed has not been adapted for satisfactory and economical work. The crushers are too small, many of them are of old design and they are not fitted up to do the work in the most economical manner. A very few unit plants of large size, with the latest improvements and devices for rapid and economical work, located at ledges with a sufficiently high face to permit of cheap quarrying, and where the ratio of stripping to rock would be small, would undoubtedly produce more economical results, even if the product had to be shipped or hauled longer distances to the points where it is to be used.

3. The purchase of the quarry property by the city would have avoided the payment of large royalties to owners, and would have given the city the benefit of the increase in value due to the grading down of the property. While the royalties paid have not, as a rule, been excessively high, the aggregate sum paid out on that account would doubtless have much more than met interest charges had the property been purchased.

4. While the rock has usually been quarried and delivered to the crushers by contract, the contracts have been carelessly and inadequately prepared, the city's interests have not been properly guarded, and the prices paid have been often, if not usually, exorbitant. Such contracts have generally been let for short periods, without public and apparently without private competition; they have been terminable at the will of the Street Department, and contractors could not, therefore, make proper arrangements for the permanent and economical handling of their work. In placing these contracts and fixing the price to be paid this price has nearly always applied to both rock and stripping, without any apparent regard to the ratio of stripping to rock or to the probable actual cost of the work.

5. The crushers themselves have evidently been operated without the intelligent supervision necessary to secure economical results.

6. The staff employed to operate each crusher has been unnecessarily large, and this staff has been continued under pay for long periods when the crushers were idle.

7. The cost of producing crushed stone under this system has been exorbitant. Municipal commissions and private contractors have been able to purchase crushed stone delivered upon the street where it was to be used at prices very much lower than the cost of the city-crushed stone at the city crushers.

8. A part of this excessive cost has been due to the practice of carrying city employees on the crusher pay rolls during the winter months, these employees, if not wholly idle, rendering no adequate return for their wages, and to carrying certain classes of employees on the crusher pay rolls through long seasons when the crushers were not operated. Either this has been done or the pay rolls are fictitious or "padded."

9. The city should at once abandon the stone-crushing business and should contract for whatever supply it may need for its public work. Contracts should be made for a considerable number of years, preferably not less than five, and should be awarded to the lowest responsible bidder after public competitive bidding, the stone to be delivered at such railroad sidings or other points as the city may designate from time to time. A sufficient storage capacity should be provided by the city to tide over interruptions or emergencies.

10. It is confidently believed that by thus contracting for the supply of crushed stone needed the city could save from $50,000 to $100,000 annually.

CHAPTER II.

STREET AND ROAD CONSTRUCTION AND REPAIR IN BOSTON.

A study of the methods and costs of street paving in Boston is somewhat complicated by the fact that improvements of this kind are usually carried out partly by contract and partly by work done directly by the city forces. This feature of the situation will be developed and discussed later on in this report. Ordinarily the *work* on the street is largely done by contract, but the city furnishes a large part of the supplies required, delivered to the contractor on the street.

In the case of certain kinds of roadway pavement, such as sheet-asphalt, bituminous concrete and wood-block, the pavement proper is constructed by contract.

The prices paid to contractors for paving of the above named varieties early attracted my attention, and the matter was looked into with some care.

PRICES PAID FOR CERTAIN KINDS OF PAVEMENT.

The prices paid to contractors for constructing sheet-asphalt, bitulithic and wood-block pavements in Boston for the past years have all been, in my opinion, excessive. This statement applies to the pavements proper rather than to the incidental work embraced in the contracts.

The contract prices for such incidental work appear to be, usually, fair and reasonable and conform closely to the prevailing prices for similar work in the city.

What follows relates more particularly to pavements constructed during the years 1906 and 1907, though the data for the last-named year is not complete, the report for that year not having been published when the study was made.

Sheet-asphalt Pavements.

For many years past contracts for constructing sheet-asphalt pavements in Boston have been awarded without competitive bidding. Three contracting firms engaged in this kind of work seem to have been pretty constantly in the field since 1899. One of these has had contracts for work every year during that time, one had contracts each year except 1904 and 1905, and the third had contracts in the years 1900, 1901 and 1906. Another company had a small contract in 1900, but seems to have abandoned the field thereafter.

The prices paid during the seven years (1900 to 1906, inclusive) have been uniformly as follows:

Pavements of Sicilian Asphalt.

For pavement consisting of a 6-inch concrete foundation and a 2-inch surface, per square yard	$3 25
For a pavement consisting of a 2-inch surface only, per square yard	2 50

Trinidad and Other Like Asphalts.

For a pavement consisting of a 6-inch concrete foundation, a 1½-inch binder course and a 1½-inch surface, per square yard . .	$3 25
For a pavement consisting of a 1½-inch binder course and a 1½-inch surface course, per square yard	2 50

All these prices include a ten-year guaranty on the pavement.

Two small contracts were let in 1900 at prices somewhat below the above, but they are unimportant.

Two things are especially noticeable in these contracts and prices.

First. — The prices have been uniform during the period of years considered, regardless of varying prices of labor and supplies and of the local conditions which would more or less affect the actual cost of the work on different streets.

The specifications have remained practically the same during the whole period, except that in the contracts for 1906 and since Portland cement was substituted for American natural hydraulic cement, previously used, for making the

concrete foundation. This change probably increased the cost of the concrete foundation about 12 cents per square yard of 6-inch foundation. No change was, however, made in the prices of the pavement because of this additional cost of the foundation. The substitution of Portland cement was undoubtedly an improvement and greatly increased the strength of the foundation.

The character and location of the street to be paved affects materially the actual cost of the paving. It is more expensive to pave a street having car tracks than one without them. The distance from the asphalt mixing plant affects the cost of hauling the material to the street. The cost of maintaining the pavement through a ten-year guaranty period is greatly affected by the quantity and character of the travel over the street, and this cost may vary, for a 10-year guaranty, from five cents per square yard on suburban streets of very light travel to as much as 30 cents per square yard on business streets of heavy travel. Other circumstances also cause this cost of maintenance to vary on different streets. All these conditions affecting the cost of the pavement seem to have been ignored in fixing the price for individual streets in Boston.

Second.— The prices paid for asphalt pavement during this period are excessively high.

The actual cost of constructing an asphalt pavement in different cities varies within quite wide limits, and all the conditions prevailing in any city must be known to estimate intelligently the cost in that city. I have, after looking into the conditions in Boston, made up an estimate of the cost and of the reasonable price for sheet-asphalt pavement constructed with Trinidad or Bermudez asphalt in Boston in the year 1906. This estimate assumes that the pavement is constructed in strict accordance with the Boston specifications, that the materials used are first class and that the work is done carefully and properly. It assumes that the street paved is one of average travel, without car tracks, and that all the conditions are such as might be expected on the average street. It is based further upon the assumption that an average area of 12,000 square yards of pavement is laid per

year by the contractor, this being about the average quantity of work done per year by one of the Boston companies. This estimate per square yard of pavement is as follows:

Fixed charges: interest, depreciation, taxes, insurance, etc., on plant	$0 25
General expenses of management	20
Local management	15
6-inch concrete foundation	70
1½-inch binder course, laid	27
1½-inch surface course, material and manufacture	39
Hauling and laying	10
Cost of contractor's bond	02
	$2 08
Add 15 per cent for profit	31
	$2 39
Add for ten-year guaranty	15
Total, reasonable price	$2 54

A similar estimate for laying the pavement proper, that is, 1½ inches of binder and 1½ inches of surface, would be as follows:

Fixed charges	$0 25
General expenses	20
Local management	12
Preparing and cleaning old foundation	03
Binder, laid	27
Surface, materials and mixing	39
Hauling and laying	10
Bond	02
	$1 38
Add 15 per cent profit	21
	$1 59
Add for ten-year guaranty	15
Total, reasonable price	$1 74

The first two items in these estimates, amounting to 45 cents per square yard, may require some explanation. The business of constructing asphalt pavements differs from that of building other kinds in that it requires an expensive plant, the cost of maintaining which goes on whether it is at work or not, or whether the quantity of work done is large or small. The work being of a more technical character, and requiring

greater skill than other pavements, as well as large capital, a permanent general organization is desirable if not essential for those who engage in the business, and large general expenses are thus necessarily incurred, which must be charged against the work done in the several cities. The charges to these accounts in the above estimate, while seeming large, are not unreasonable.

If the contractor is engaged in other lines of work, such as private paving, roofing or waterproofing, the fixed charges and some of the cost of local management would be properly shared by such outside work. This has not been overlooked in making up the above estimates, and while the books of the contractor might show larger charges to the pavement work, I have no doubt that a company equipped for laying an average quantity of 12,000 square yards per year, and economically organized and managed for the doing of that work alone, could have done the work in the year 1906 at the cost and with the profit named in these estimates.

To the cost thus arrived at should be added, where the street contains car tracks, about five cents per square yard.

As the prices in Boston have been uniform they may be assumed to be the average prices paid in that city. Comparing them with the above estimates of average cost and reasonable price it will be seen that they are excessive. Thus, the price for:

Foundation, binder and surface is	$3 25
The above estimate, less the item for profit, is	2 23
Actual profit, per square yard	$1 02

and the rate of profit is nearly 46 per cent.

For binder and surface alone the price has been, per square yard,	$2 50
The above estimate, less the item for profit, is	1 53
Profit	$0 97

and the rate of profit is 63 per cent.

Comparisons with the prices paid for sheet-asphalt pavement in other cities are not of much value unless all the conditions are known and taken into consideration. But it may

be of interest to note that in the borough of Brooklyn, New York City, the average price paid in the fiscal year 1906 for sheet-asphalt pavement with 5-inch concrete foundation, 1½-inch binder and 2-inch surface, is stated to have been, on streets without tracks $1.48 per square yard, and on streets with car tracks $1.65 per square yard. In both the boroughs of Manhattan and Brooklyn the average price paid for 1½-inch binder and 2-inch surface did not exceed $1 per square yard. The quantity of work done was large, and the guaranty was for five years only.

In the City of Buffalo, N. Y., the average price paid for sheet-asphalt pavements in the fiscal year 1905–06 seems to have been, as nearly as can be determined from the printed reports, $1.62½ per square yard for binder and surface. About 56,000 square yards of the pavement were laid during the year.

The two contracts for paving different sections of Columbus avenue in 1906, which aggregated 33,095 square yards of binder and surface, cost the city at the prices paid ($2.50 per square yard) $82,737.50.

In applying the estimated average reasonable price ($1.71 per square yard) to these contracts an addition of 5 cents per square yard should be made because the street has car tracks. The contractors were also required to take up and haul away the old asphalt surface for which a fair allowance would probably be 8 cents per square yard, making the reasonable price $1.87 per square yard. At this price the work would have cost the city $61,887.65, or $20,849.85 less than was paid to the contractors.

Up to the end of the fiscal year 1906 about 208,000 square yards of American sheet-asphalt pavement had been laid in Boston. As this pavement cost more in the earlier years, during which a part of it was laid, it would not be fair to apply the above estimates of present cost to the whole of it. But I think we may safely say that the cost was at least 40 cents per square yard more than it should have been. If so, the loss to the city must have been at least $80,000.

The cost of imported rock-asphalt pavements (Sicilian, Seyssel, etc.) is somewhat higher than those made of Ameri-

can asphalts, owing to the higher cost of the material, but as their use in Boston has been practically discontinued they need not be considered here.

REPAIRING ASPHALT PAVEMENTS.

After the period of guaranty upon a pavement expires the cost of maintenance must be borne by the city. In Boston the repairing of such pavements has been provided for under contracts which have, for several years, been awarded to one company without competitive bidding, at the uniform price of $2.50 per square yard of binder and surface repaired. It is difficult to estimate with any certainty the actual cost of making such repairs because of the varying conditions under which the work must be done. Laying small patches scattered over different streets is necessarily more expensive than constructing large areas of new pavement. On February 6, 1908, the city opened competitive bids for such repairs during that year, and a bid was submitted at a price of $1.73 per square yard of binder and surface repaired. While this price may not yield much, if any, profit to the contractor, it shows, at least, that the prices previously paid for the same kind of work were much too high.

BITUMINOUS CONCRETE PAVEMENTS (BITULITHIC).

The first pavements in Boston of this kind were laid in 1902. The quantities laid each year have been as follows:

1902	9,878 square yards.
1903	31,840 square yards.
1904	18,196 square yards.
1905	33,766 square yards.
1906	14,106 square yards.
1907	7,289 square yards.
Total at end of 1907	115,075 square yards.

This pavement has all been laid by one company at a uniform price of $2.50 per square yard. There was no competitive bidding; the pavement is patented, the patents are controlled by the company doing this work, and competitive bidding might, therefore, have been useless.

The crushed stone for the foundation was furnished and

delivered on the street by the city, and the contractor's price for the pavement includes the placing and rolling of the crushed stone foundation, the bituminous concrete surface, and the ten-year guaranty.

While I have had no actual experience in the construction of this kind of pavement, the cost of bituminous concrete is not difficult to estimate. Such estimates show that the charges, general and local expenses, material and labor, 15 per cent profit, and a liberal allowance for the ten-year guaranty, should not have exceeded $1.70 per square yard.

The price paid per square yard was	$2 50
A reasonable price would have been	1 70
Profit	$0.80
Rate of profit	46 per cent

To obtain the full cost of the pavement to the city the cost of the crushed stone used in the foundation must be added to the contract price for the pavement.

The quantity of stone required was, per square yard, about 0.225 ton.

The cost per ton of the crushed stone delivered on the street may be estimated as follows:

Crushed stone at crushers, city price	$1 60 per ton.
Hauling to the street	40 per ton.
Total	$2 00 per ton.
At which price the cost of 0.225 ton would be	45 per ton.
Which, added to the contract price for the pavement, makes, per square yard	2 95 per ton.

I have no doubt that if the pavement were not patented and contracts were let upon competitive bidding the city would obtain a price for the whole pavement, including foundation and surface, not exceeding $2.30 per square yard.

The whole cost of all the pavement of this kind laid up to the end of 1907 was, according to the above figures:

115,075 square yards at $2.95	$339,471 25
If the work could have been secured at the above estimated price of $2.30 per square yard the cost would have been	264,672 50
A difference of	$74,798 75

WOOD-BLOCK PAVEMENTS.

The first creosoted wood-block pavement was laid in Boston in 1900. The total area constructed up to January 1, 1908, seems to be about 42,000 square yards.

The prices paid under the contracts for 1906 and 1907 have been uniformly $1 per square yard for the concrete foundation and $3.25 per square yard for the wood-block pavement, making the price for the pavement complete $4.25 per square yard.

These prices, both for the concrete and for the wood-block, are excessive; but it is difficult to estimate a reasonable price for the wood-block pavement during the last two years. The prices of lumber, creosote oil and resin have been rising rapidly, and have fluctuated quite widely, and unless one knew the date when the supplies were bought it is not possible to figure costs correctly. There is also some uncertainty about the quantity and character of the preservatives used in the treatment of the blocks, which also affects the cost.

A still more uncertain matter is the cost of maintaining the pavement through the ten-year guaranty on streets of heavy travel, which I anticipate will be large. Our experience with these pavements in this country is not sufficient to warrant estimates of the cost of guaranty repairs, and possible renewal, during so long a period. Disregarding this item of maintenance and contractor's profit, the actual cost of constructing the pavement probably did not exceed, on these contracts, $2.80 per square yard for the 6-inch concrete foundation, the ½-inch mortar bed and the wood paving, 3½ inches deep, all complete. As the price paid was $4.25 per square yard, there was a margin to cover guaranty charges and profit of $1.45 per square yard.

In all the more recent contracts the price for the concrete foundation has been $1 per square yard. If these foundations were the full 6 inches in thickness the price was at least 25 cents per square yard too high.

A statement filed with the contract for paving Washington street, between Milk street and Beach street, apparently

as a justification for awarding the contract without advertising for bids, contains the following:

> The United States Wood Preserving Company is the only reputable company furnishing and laying wood-blocks in this section. The prices allowed average but do not exceed the prices paid to the same company in New York City, where it has been awarded, as the lowest bidder, contracts for about 180,000 square yards of wood-block paving.

The latter part of this statement is not in accordance with the facts. In eight of the largest contracts, aggregating 83,371 square yards, executed in New York in 1906, the average price for concrete was $6.21 per cubic yard, equivalent to $1.03 per square yard of 6-inch foundation, and the average price for the wood-block pavement was $2.85 per square yard. Only two small contracts, aggregating 1,877 square yards, were carried out in 1907, the prices for each being $5.95 per cubic yard for concrete and $2.85 per square yard for the wood-block pavement. All these pavements are on heavy-traveled, down-town streets, and the guaranty is for ten years. Because of the heavier travel to which they are subjected the cost of maintaining these New York streets through the guaranty period will undoubtedly be greater than on the Boston streets. The wood-blocks probably cost a little but not much more in Boston than in New York because of longer transportation. On the whole, the prices paid in Boston for the pavement proper are at least 40 cents per yard higher than those paid in New York in 1906 and 1907.

COMMENTS.

The very high prices paid in Boston for asphalt, bitulithic and wood-block pavements have doubtless been due largely to the absence of competition. Competitive bidding might not, however, have resulted in much reduction in the prices. Bitulithic pavement, being patented, is admittedly a monopoly. Wood-block paving is practically a monopoly in Boston (and in New York also) because of the very close business relations of the various companies engaged in the preservative treatment of wood on the Atlantic coast. While, nominally, separate contractors are engaged in asphalt pav-

ing in Boston, it is doubtless the fact that they are all practically controlled by the "Asphalt Trust."

But these conditions offer no excuse for awarding paving contracts at prices that are clearly exorbitant. The city officials could learn and should know what are fair and reasonable prices in Boston for the several kinds of pavement and might and should refuse to award contracts for paving at excessively high prices.

COLUMBUS AVENUE PAVING CONTRACTS.

In connection with and immediately following the above inquiry into the prices paid for certain kinds of pavement, a more extended examination was made of the facts relating to the improvement of Columbus avenue, which was repaved with sheet-asphalt during the years 1906 and 1907. A study of the information collected is here presented, as this improvement may be regarded as typical of contract and city work on the construction of the special kinds of pavement we have been considering.

The repavement with sheet-asphalt of Columbus avenue from the Boston & Albany railroad bridge to a point about 60 feet north of Station street was carried out in the latter part of 1906 and the early part of 1907. The work to be done consisted of removing the old asphalt surface, readjusting the old concrete foundation outside the car tracks, setting required edgestone and flagging, and resurfacing with sheet-asphalt that part of the roadway outside of the part paved with granite blocks in street railroad tracks; also of paving that part of the street within and between the tracks and a strip outside of the outer rail, called the "brows," with granite block paving, together with necessary incidental work.

The contracts for this work were awarded without competitive bidding. It is stated that the first intention was to award the whole contract to a single company, but it was later decided, for reasons not publicly stated, to divide the work between the Barber Asphalt Paving Company and the Boston Asphalt Company about equally. A contract dated August 31, 1896, was made with the first-named company for the work from the Boston & Albany Railroad bridge

to Camden street, and another contract, dated September 4, 1906, was made with the Boston Asphalt Company for the work from Camden street to Station street. Both contracts were approved by the Mayor. The terms of the two contracts, and their specifications, are practically identical.

The specifications are remarkably incomplete and indefinite. It is difficult to determine whether certain materials are to be supplied by the contractor or by the city, and the exact parts of the work that are to be done by the contractor. For instance, it is nowhere stated which party shall supply the granite blocks for the paving within the car tracks.

The general character and the quantities of work the contractor is to do are stated under the head of "Estimates," but the full details of the work to be done cannot, of course, be inferred from this brief estimate.

Both companies seem to have begun their work promptly. The Barber Asphalt Paving Company completed its work on April 12, 1907, and the work of the Boston Asphalt Company was completed May 8, 1907.

So far as can be learned the work done and the supplies furnished was divided between the city and the contractor as stipulated in the specifications, with some possible exceptions (where the information is not clear, or is wholly wanting). Most of the work about which question might be raised was covered by written orders for extra work from the Superintendent of Streets, issued during the progress of the work, and the final estimates contain allowances for such extra work, amounting, on both contracts, to about $4,500.

It is quite possible that the circumstances justified the classification of these extras as work which the contracts did not require the contractor to do; my knowledge of the conditions is not sufficient to warrant an opinion in the matter.

Some of the items allowed for this extra work seem rather extraordinary. For instance, under an order issued to the Boston Asphalt Company, September 18, 1906, to "Cut Concrete for Brows," there was an allowance, in the final estimate, of $721.95, $155 of which was for *teams*.

So far as can be determined by surface observation at the present time the work of the contractors was reasonably well done, and the pavement is now in fair condition, with exceptions named below. The quality of the work done below the surface cannot be determined without cutting into the pavement extensively, which seems inadvisable at this time. The asphalt surface adjacent to the rails is, in many places, in poor condition and has already been repaired quite extensively. It is difficult to fix the responsibility for these defective strips along the rails without a full knowledge of the facts and the conditions under which the work was done. Asphalt surface laid directly against the rails will rapidly disintegrate unless the tracks are so firmly supported as to be practically free from oscillation or vibration. In a number of places on this work there are indications that the rails are not as firm as they should be and that the track has settled sufficiently to fracture the pavement adjoining the rails.

If the pavement is laid in cold weather the hot asphalt material in contact with and near the rail becomes chilled before it can be promptly compressed and the resulting spongy material cannot resist the travel over it, which is usually concentrated along the rails. I am told that a considerable part of the asphalt surface was put down in very cold weather, when it is impossible to do the work properly. This should not have been permitted by the city. There are numerous places which have the appearance of being laid when the temperature was too low, and a few small areas where the material appears to have been overheated, probably with the object of counteracting the effects of the low temperature when the work was done.

The question whether the binder and surface courses were laid of the full thickness required by the specifications can hardly be determined by cutting into them so long after the work was done. If an accurate record had been kept of the quantity of material used, the thickness to which it was laid could be computed. On one contract the inspector made an effort to keep such a record, but it is not sufficiently exact to be safely relied upon. It indicates that the surface course, at least, was laid to the full thickness required by the specifications.

The prices received by the contractors for the pavement has already been referred to and need not be considered here.

Work Done by the City.

The cost of work done directly by and at the expense of the city under the two contracts is shown by the ledger to be as follows:

Labor	$4,052 20
Holidays	45 95
Stone	2,475 08
Edgestones	108 76
Flagging	946 43
Nails	4 90
Car fares	10 34
Brick	1,745 25
Cement	3,096 25
Lumber	540 57
Blocks	24,243 05
Teaming	38 73
Hired teams	11,443 50
Tolls	16 40
Relaying, W. Newton	344 13
Total	$49,111 54

It has been found practically impossible to satisfactorily verify these items either from the original records or from information obtainable from the department, the inspectors on the street or other city employees.

Labor.

The charge to "labor" is made up as follows:

Engineers	$2,490 11
Sub-foreman	388 50
Inspectors	332 50
Janitor	53 00
Stonecutters	448 50
Carpenters	181 54
Sheet-iron worker	91 50
Watchmen	36 00
Laborers	64 50
Patch-paver helper	12 00
	$4,098 15
Of which sum there was charged off for holidays	45 95
Net labor charged to street	$4,052 20

According to the time books all this labor (except the charge for engineers) was performed between the thirteenth day of September, 1906, and the ninth day of May, 1907.

The sub-foreman, William Donohoe, seems to have worked overtime during much of the period. During each of eight weeks he made 7½ days' time, during two weeks he made 9 days per week and during one week he got in 10 days' work, or, counting 8 hours as a day's work, he is credited with 1.43 days' work for every day of the week, including Sunday. For five successive weeks he averaged over 1¼ days' work every day, including Sundays.

James Whooler, inspector, worked almost as hard, having averaged, for 12 successive weeks, 1.08 days' work every day, including Sundays. The janitor is said to have been employed to watch the teams and keep them at work. The carpenters and sheet-iron workers ($273.04) are said to have been necessary for some bulkhead work that had to be done.

It will be observed that the charge for "laborers" is only $64.50. This is surprising, since the city delivered on the street a large quantity of supplies and there must have been a very considerable amount of help required in loading and unloading such materials as granite blocks, edgestones, etc. The time sheets for "teaming" contain no charges for such labor, except as it may have been done by the drivers.

Hired Teams.

The charge for teaming, amounting to $11,482.23, seems to be excessive. Of this sum $11,443.50 was paid for hired teams. There is no doubt that this sum was actually paid out by the city, but it is not possible to verify the pay rolls nor to classify the charges to the various kinds of supplies hauled. No observations or records were made of the number of loads of material hauled each day by each team. The system (or rather lack of system) employed afforded no means of recording the number of loads of material hauled nor (apparently) the actual time each team worked. It is not clear that teams may not have reported for duty in the morning, but did little or no work, or they may have gone away to haul for some one

else. It seems that it would have been quite possible to do either. It is possible, also, that the teams did not do a fair day's work for a full day's pay.

Information as to the quantities of supplies hauled and the distances over which they were hauled has been collected and analyzed, and after making the most liberal reasonable estimate of the time required not more than 1,440 team-days can be thus accounted for.

There may have been some miscellaneous hauling not included above, and it is stated that in some cases where the material was not at first properly distributed it was necessary to reload and haul it for short distances. If we add 20 per cent to the above number of team-days to cover these additional items, and to allow for unavoidable delays, etc., we shall have 1,728 days' hauling. This must be considered a very liberal estimate, and if the work had been done by contract under proper supervision the above team-time would doubtless have been materially reduced.

The estimate is based upon the use of double teams exclusively, but the pay rolls show that a considerable number of single teams were employed, though they were, for the greater part of the work, less economical than double teams.

At $5 per day, the rate paid for double teams, 1,728 team-days would amount to $8,640. As the total charge for hired teams was $11,443 there remains a balance of $2,803 unaccounted for upon any reasonable estimate of what the cost should have been.

Crushed Stone.

The ledger charge for crushed stone used on the improvement is 1,546.92 tons at $1.60, amounting to $2,475.08. The quantity is based upon the records kept at the Columbia road crusher. The final estimate returned by the City Engineer gives the quantity as 1,506.3 tons, while an examination of the teaming slips received on the street and returned to the engineer's office fails to show the receipt upon the street of more than 1,412.13 tons, or 134 tons less than the crusher books show was sent out and 94 tons less than is charged for in the ledger account. These discrepancies may be due to the careless manner in which the slips issued at the crusher for

each load sent out were handled and cared for on the street and returned to the engineer's office. But the fact remains that the actual quantity of stone used on the street cannot be determined from original records.

The long haul from the Columbia crusher to the street, averaging 3¼ miles, made the cost of delivery high — about $1.10 per ton. As the cost of producing crushed stone at the Columbia crusher during 1906 averaged $2.26 per ton (see page 34) the total cost of the stone delivered on the street must have been about $3.36 per ton, though it was charged to the improvement at only $1.60 per ton. If the stone had been charged to the work at $2.26 per ton it would have added $1,021 to the cost of the improvement. If the stone had been bought by contract at $1.10 per ton and delivered at convenient points on the Providence branch of the New York, New Haven & Hartford Railroad (which runs parallel with and very near to the improvement) it could have been hauled to the street at a cost of not exceeding 50 cents per ton, making the total cost $1.60 instead of $3.36 per ton, and the saving would have amounted to over $2,600. The foreman of District No. 8 yard states that a considerable quantity of crushed stone was sent from his yard to grade up connections with intersecting streets. This was presumably charged to the repair of these streets, but it is possible that the discrepancy in quantities referred to above may be due to confusion in separating the quantity that should be charged to Columbus avenue.

These discrepancies as to quantity are not very important except as an illustration of the loose methods of following and accounting for supplies used in city work. It was entirely practicable to trace every ton of the crushed stone used from the crusher plant to the street and to its record in the city accounting department in such a way as to fix the responsibility for it at every stage of the proceeding, as well as to check the quantity hauled each day by each team employed, and in this way to have verified the pay roll of the teams engaged in the hauling. This statement applies as well to all other supplies as to crushed stone.

Edgestones.

The various yard records show that 86⅔ linear feet of straight and 10 feet 7 inches of circular edgestone was sent to the street, but the ledger account, made up from the records of the engineer's office, show that only 49 feet by 10 inches of straight and 5 inches by 7 inches of circular edgestone were actually used on the work. What became of the balance sent to the street cannot be learned.

Flagstones.

There were sent to the street from the Albany street yard 884 feet 4 inches of flagging, and 251 feet 10 inches was delivered direct from the dealer, making in all 1,136 feet 2 inches, and the ledger account is based on this quantity, but the yard reports to the engineer's office give 891 feet 2 inches as the quantity sent out to the work.

Hydraulic Cement.

One thousand two hundred and forty barrels of hydraulic cement were reported as used on the work. Of this, fifteen barrels were charged at $2.25, and the balance at $2.50 per barrel, making the sum charged to this item $3,096.25. According to the inspector's testimony the greater part of this cement was delivered in cloth. If so, the prices paid were grossly excessive. While I have no exact data as to the open market price of cement in Boston at that time, I do not think it could have exceeded $1.50 per barrel delivered in cloth upon the streets as wanted.

There is no data from which to estimate accurately the quantity of cement that was actually required for the work, but from the best information obtainable the quantity charged seems not to have been excessive.

Granite Paving Blocks.

The city originally purchased for this improvement:

	384,670 blocks at 7 cents,	$26,926 90
Later, there were purchased, delivered on the street.....	1,200 blocks at 6½ cents,	78 00
Totals.....	385,870 blocks	$27,004 90

The actual charge on the ledger was originally $26,964.65. Later, an additional charge for 1,570 blocks at 7 cents ($109.90) was made, and the account was credited with 40,450 blocks, said not to have been used on the work, at 7 cents ($2,831.50), making the net charge as it now stands on the books $24,243.05, for, apparently, 1,200 blocks at 6½ cents and 346,645 blocks at 7 cents, a total of 347,845 blocks used.

The records show:

That there were sent to the street from the South End yard,	341,600 blocks.
From Yard No. 7	675 blocks.
Also that there were purchased, delivered on the street, from other parties	1,200 blocks.
Total	343,475 blocks.

The Engineering Department records show:

That there were sent out from yards	350,645 blocks.
Bought on street	1,200 blocks.
	351,845 blocks.
And that there were sent back to yard.	275 blocks.
Net number used	351,570 blocks.

The team slips show that the number of:

Blocks delivered was	340,195 blocks.
If we add those bought delivered on street	1,200 blocks.
Total	350,395 blocks.
And credit those returned	275 blocks.
The number would appear to be	350,120 blocks.

None of these quantities agrees with the computed number of blocks required for the work.

The final estimates give as the area of the granite block pavement	17,846 sq. yds.
But of this area there was laid, to connect up intersecting street pavements, for which old blocks were used	1,060 sq. yds.
Leaving area paved with new blocks	16,786 sq. yds.
Furthermore, the surface of the rails, amounting to about 1,560 square yards, was measured in and paid for as granite pavement and should be deducted in arriving at the number of blocks required	1,560 sq. yds.
Net area paved with blocks	15,226 sq. yds.

Ordinarily about 23½ blocks are required to lay 1 square yard, but in track work, where many blocks must be broken to make "closers" against the rail, there is a considerable loss of material and it is fair to figure 25½ blocks per square yard. Upon this basis 388,263 blocks would be required. This is 36,693 blocks more than the number reported as used by the Engineering Department, and 40,418 more than are charged to the street.

It has been found impossible to verify or harmonize the conflicting accounts of the number of blocks said to have been used in the work, but it seems clear that a much larger number of blocks were used than are now charged up to the street. Apparently the number of blocks charged in the original account was not very far wrong.

Some discrepancies in the accounts of the number of blocks used are to be expected. Where they are counted (if counted at all) by different people, with no incentive to great accuracy, some differences would be sure to occur.

Because of the difficulty of counting accurately such large numbers of paving blocks as are used it is better to buy them by the square yard of pavement laid, as is done in a number of cities, though Boston is not alone in buying them by the thousand. If thus bought by the square yard discrepancies due to the varying average size of the blocks would also be avoided.

Area of Pavement Paid for.

Because of the discrepancy in the accounts of the number of blocks used and the apparent inadequacy of that number for the work, we have made some measurements and computations to verify the engineer's estimate of the area of the granite pavement laid and find the quantity substantially correct.

As previously stated the area of the rails was measured in and paid for as pavement in the final estimate. It is the practice to do this in a number of cities because it is, practically at least, as expensive to lay pavement within and between the tracks as it would be if no tracks were upon the street and the whole area were paved, the idea being that the additional cost is not more than compensated for by measuring

the rails as pavement. When the rails are not included in the area paid for a higher price is reasonably charged by the contractor. The Boston specifications are silent as to whether the area of the rails is to be included in the area of the pavement paid for, but the proposal submitted by the contractor names a price for "each square yard laid," and a strict interpretation of this language would exclude the area occupied by the rails.

The matter of city work and supplies on this Columbus avenue work has been gone into here in more detail than its importance on this particular improvement would warrant, because it seems to present a fair illustration of the methods and practices in vogue in Boston in all city work, in the street paving department.

Estimated and Total Cost of the Work.

The engineer's preliminary estimates of the cost of the Columbus avenue improvement were as follows:

Barber Asphalt Paving Company, Contractor, contract work	$63,000	
Barber Asphalt Paving Company, Contractor, city work	28,000	
Total		$91,000
Boston Asphalt Company, Contractor, contract work	$65,000	
Boston Asphalt Company, Contractor, city work	23,000	
Total		88,000
Grand total		$179,000

The actual cost of the work as shown by the city records was:

Barber Asphalt Paving Company, contract and extra work	$67,580 31
Boston Asphalt Company, contract and extra work	67,047 95
City work	51,833 14
Total	$186,461 40

From which it appears that the actual cost exceeded the estimated cost by $7,461, or a little over 4 per cent, which may be regarded as a close estimate.

So close an estimate would hardly have been possible except for the fact that the prices for the principal items of work were practically known when the estimate was made, having become uniform through custom and the absence of competitive bidding.

It is noticeable that the actual cost of the city work exceeded the estimated cost by only $833. This close agreement is remarkable when the apparently loose and unsystematic methods of handling and accounting for city supplies is considered.

The cost of the work done and the supplies furnished by the city amounted to 38 per cent of the total cost of the work.

The estimated and the actual quantities of the different items of work were as shown in Table No. 27.

Table No. 27.

Estimated and Final Quantities, Columbus Avenue Contract.

ITEMS.	BARBER ASPHALT PAVING COMPANY.		BOSTON ASPHALT COMPANY.		BOTH CONTRACTS.	
	Preliminary.	Final.	Preliminary.	Final.	Preliminary.	Final.
Preparing site, square yards	1,000	2,776	2,000	3,585	3,000	6,361
Edgestones, linear feet	4,600	5,354	7,666	7,818	12,266	13,172
Concrete base, square yards	4,674	4,405	4,025	2,826	9,079	8,231
Crosswalks, square yards	735	516	430	269	1,165	785
Concrete, extra, cubic yards	1,022	1,379	1,600	1,363	2,622	2,742
Binder and surface, square yards	16,314	16,856	16,074	16,239	32,388	33,095
Binder, extra	100	3	35	18	135	21
Granite block paving, pitch	8,755	8,789	7,968	7,997	17,544	16,786
Granite block paving, gravel	100	421	1,000	639	1,100	1,060
Brick sidewalks, square yards	7,313	7,001	9,672	9,869	14,314	16,870
Concrete chipping	525	376	—	—	525	376
Loam, cubic yards	—	—	200	—	200	—

The agreement between the estimated and the actual quantities is as close as could be expected on a work of this character and magnitude, as some of the quantities could not be accurately determined until the street was opened.

Upon the whole, the work of the Engineering Department,

including the inspection of the work in progress, seems to have been well done, except in the matter of recording and accounting for supplies furnished and work done by the city.

The question arises, what would have been the cost of this improvement at fair and reasonable prices.

On page 90 it is stated that a fair price for the asphalt pavement would have been $1.87 per square yard. Ninety cents per square yard would have been a reasonable price for the granite block pavement laid in the tracks, with the area of the rails included in the measurement of the pavement. It is hardly possible to say, in the absence of needed data, what would have been the reasonable cost of that part of the work done by the city, but I think we may safely assume that a saving could have been effected in some of the items, as follows:

Crushed stone, 1,547 tons at 50 cents ($1.60—$1.10)	$773 50
Cement, 1,200 barrels at $1 ($2.50—$1.50)	1,200 00
Teaming	3,000 00
Total	$4,973 50

The total saving may, therefore, be figured as follows:

33,095 sq. yds. asphalt pavement at 63 cents ($2.50—$1.87)	$20,849 85
16,786 sq. yds. granite pavement at 15 cents ($1.05—$0.90)	2,517 90
Saving on city work (as above)	4,973 50
Total	$28,341 25

The actual cost was, as shown above, $186,461.40, from which it appears that the work cost over 18 per cent more than it should have cost.

It does not appear that the work was credited with the value of the old paving blocks taken up and removed from the street. Such credit would have decreased the total cost of the work, but would not have altered the estimated excessive cost figured above.

STREET IMPROVEMENTS AND THE MAKING OF HIGHWAYS.

A very large sum of money is expended by the Street Department each year for the repair or reconstruction of old streets, called "Street Improvements," the cost of which

is wholly paid for by the city, and for the building of new streets, called in the reports "Making Highways," a part of the cost of which is assessed upon the adjoining property benefited.

The expenditures under these two general heads for the past three years have been as follows:

YEAR.	For "Street Improvements."	For "Making Highways."
1905	$767,707 46	$10,604 01
1906	739,139 87	66,376 34
1907	482,465 90	194,645 84

In both classes of improvements the work is usually done by a combination of the contract and the city labor methods. A contract is let for a part of the work on each improvement, while the city furnishes the bulk of the supplies and also does a part of the work.

We have examined and made abstracts of over 160 contracts for such improvements in the years 1906 and 1907, and have obtained from the city books the amounts expended upon each, in addition to the amount paid to the contractor. The sum of the two gives the total cost of the improvement.

It was found that while the contract work and the accounts relating to it were comparatively simple, the city work was complicated and unsatisfactory. In a great majority of the cases the data thus obtained from the books was not in sufficient detail or so classified as to make possible an intelligent analysis of the cost. An effort was made to supplement the records by obtaining information from the engineers, inspectors and foremen who had been engaged on the work, but without very much success. The examination into this class of contracts and the study of the abstracts and data proved to be tedious and required a great deal of time and work, and the results have often been incomplete and unsatisfactory.

In the contract work the itemized quantities, prices and amounts are shown by the books, but in the city work the

expenditures are classified under topical heads which give no clue to the cost of the various items of work. Thus all hauling of supplies and waste material is charged simply to "Hired teams" or "City teams"; there is no attempt to separate the amounts into charges against the several items of work, such as granite paving, edgestone, flagging, brick, sidewalk, etc. The same is true of "labor" and of other charges.

Generally the data from the books enable us to consider the reasonableness of the several charges only with reference to the cost of the job as a whole. The cost of specific items or parts of the work, which is of most importance in analyzing the cost, is difficult or impossible to obtain with certainty, and the conclusions arrived at may not always be accurate and just.

The typical history of this class of improvements seems to be as follows: When it is determined to repair or improve a street, say, under the title of "Paving and Regulating," a contract is entered into without advertising for proposals, and presumably without competition, to do a part of the work. In the great majority of cases this contract embraces the necessary grading and the work of actually putting in place the edgestones, the granite gutter paving and the sidewalks, with occasional other items. The city, on its part, agrees to furnish, delivered on the street, most of the supplies for the contractor's work, and, in addition, in connection with this contract work, the city furnishes the supplies for and does the work of constructing or repairing the macadam roadway. The work of the contractor and of the city may or may not progress simultaneously, and the possibility of confusing and intermingling the supplies and labor of the two would seem to be always present, though there is little direct evidence of loss to the city in that way. When the contractor's work is completed it is measured and paid for in the regular way and his final estimate is charged against the improvement. In addition to this contractor's charge, the cost of the supplies furnished and the labor expended by the city is charged to the account under topical heads, such as labor, hired teams, holidays, edgestone, granite blocks, crushed stone, gravel, sand, brick, etc., there being no indication, except as may be

inferred from the character of the improvement, as to the several parts of the work upon which the sums were expended.

Ordinarily the aggregate cost of the city work exceeds the amount paid to the contractor, and in many cases it is several times as much. In one hundred paving and regulating improvements, examined at random, the average amount paid to the contractors was 36.2 per cent and the cost of the city work was 63.8 per cent of the whole, or, roughly, the city work averaged in cost nearly double the contract work. In many cases the contractor's work seemed to be simply a nucleus around which a large city expenditure was built up. A few examples from the 1906 work will illustrate this:

	Contract Work.	City Work.
Paving and regulating C street	$9,572 25	$39,708 94
Paving and regulating Columbus avenue	1,872 39	12,581 16
Paving and regulating Carolina avenue	999 88	4,768 26
Paving and regulating East Seventh street	1,824 05	13,092 13
Paving and regulating Bradshaw street	366 95	1,766 60
Paving and regulating Washington street	496 18	6,794 35

Beyond the bare charges for hired teams, labor and supplies there is practically nothing in the records to show the character or quantities of work accomplished by these city expenditures and consequently no way of computing the unit or total cost of each kind of work. Inquiry at the engineer's office and of foremen and others engaged upon the work will usually disclose some, but not complete details. The labor and time required to investigate each of these contracts would be so great as to make it, in my opinion, inadvisable.

We have, however, looked up as carefully as practicable the particulars of a number of these contracts and analyzed the expenditures as far as possible. Some of these will be now considered and the results may be regarded as typical of the whole, although it is proper to say that these were taken up because the ordinary examination seemed to disclose abnormal conditions or excessive items of cost. They should, therefore, be considered as illustrative rather than average conditions.

CONSTRUCTING AND REGULATING DISH GUTTER, CAROLINA AVENUE, BETWEEN SOUTH AND CALL STREETS, WEST ROXBURY.

The contract for this work was awarded to Michael J. Flinn, July 27, 1906. His work was completed September 12, 1906. His final estimate was as follows:

Excavation, earth, 1,274 square yards at 50 cents	$637 00
Excavation, rock, 2 cubic yards at $1.75	3 50
Granite block pavement, 1,437.5 square yards at 25 cents	359 38
Total	$999 88

The contractor's work embraced the excavation for and the laying of granite block gutters 4 feet wide on each side of the improvement, which was 1,500 feet long. The city supplied the gravel and the granite blocks used by him, delivered upon the work, and hauled away the excavated material. Under these conditions the price he received for the excavation was very high, as he did nothing but dig up the earth and load it into wagons. His price for laying the granite block seems to be about the average paid in Boston and is reasonable. On a small part of the work old pavement was to be removed ("barred out") and relaid and the contractor was allowed 15 cents per square yard additional for this. Some other small items of work for which prices were not named in the contract were done by the contractor, but the account was so equated as to pay the contractor for all in terms of granite paving at the contract price.

Actual work done by him was as follows:

1,372 square yards straight paving, at 25 cents	$343 00
98 square yards old paving "barred out," at 15 cents	14 70
9 feet edgestone set, at 18 cents	1 62
Total	$359 32

This sum is equivalent to 1,437½ square yards of contract paving at 25 cents per square yard, which is the form in which the account appears in the final estimate. The contractor received no more than was due him, but while only 1,372 square yards of gutter pavement is actually on the street the record shows 1,437½ square yards, or 65½ yards more than

actually exists. This method of adjusting accounts seems to be not uncommon, as we have found it used in a number of instances. One objection to it is that, if the permanent records are based (as they presumably are) on the final estimate, these permanent records do not show the actual area of pavement on the street. It would be better to give the contractor extra work orders for any work outside his contract that he may be required to do.

The actual depth of the gutter excavation cannot be ascertained. It probably did not exceed one foot, and if so the contractor was paid at the rate of $1.50 per cubic yard, an exorbitant price for excavating and loading the material into wagons.

According to the terms of the contract the city furnished to the contractor, delivered on the street, the paving blocks and gravel required in his work.

The work done by the city consisted of the resurfacing of the roadway with macadam. The city work seems to have been in progress from August 10 to October 11, or about two months.

The charges shown on the ledger for work done and supplies furnished by the city, in addition to the contract work, are as follows:

Hired teams	$1,382 50
City teams	120 00
Labor	650 75
Steam roller	305 50
Crushed stone	1,855 11
Gravel	113 40
Granite blocks	276 00
Holiday account	65 00
Total	$4,768 26

The cost of this city work seems to have been excessive.

Teaming.

The charge for teaming is $1,502.50. A very liberal estimate of the hauling to be done, so far as can now be determined, would not exceed in cost $1,200, and had this hauling been done by contract the cost probably would have been considerably under that sum.

Labor.

In the class of improvement to which this belongs the cost of engineering is not usually charged against the work.

The charge for labor, including holidays, was $715.75. The allowance for holidays was $65, or a little over 9 per cent of the whole. It cannot be determined how this labor was distributed to the various items of work, but excluding a small amount probably employed in loading and unloading materials, it was chargeable to macadamizing the roadway. The labor here must have consisted almost entirely of spreading and grading the stone on the roadway, and if so the charge is grossly excessive.

Rolling.

The charge for rolling was $305.50. To properly roll a 6-inch macadam surface should not cost more, and usually costs less, than 5 cents per square yard. As the area of the macadam roadway did not exceed 2,350 square yards the cost of rolling at 5 cents per square yard would be $117.50, or less than half the amount charged.

Crushed Stone.

The charge for crushed stone was $1,855.11. As it was charged up at $1.60 per ton, 1,160 tons appear to have been used. The quantity required per square yard of 6-inch macadam does not exceed $\frac{1}{3}$ ton, and on this basis about 785 tons would have been required. The district foreman says, however, that the macadam was made 10 inches thick, because it required that thickness to bring the surface to the adopted grade. As 6 inches of macadam would have been sufficient for this street it seems singular that the material excavated from the gutters was not used to raise the grade of the roadway to the proper elevation before putting on the macadam. Not only could this material have been more cheaply disposed of in that way, but 375 tons of crushed stone could have been saved.

Gravel.

The specifications require that in gutter paving the granite blocks shall be set on a layer of gravel 4 inches thick. It is

stated, however, by the foreman that in this case the bed of gravel was only two inches thick, which would require about 80 cubic yards. The gravel required to fill the joints in the block paving and to cover its surface was probably about one cubic yard to 20 square yards of pavement, and for this purpose about 75 cubic yards would be required, making in all 126 cubic yards. About 132 cubic yards seem to have been charged up to the work.

Granite Blocks.

Twelve thousand "culled" blocks were furnished by Lombard, delivered on the street at $23 per M., amounting to $276, the charge in the account for blocks. The balance used were old city blocks hauled from Beech street and from Massachusetts avenue. There is no record of the number brought from each street, or the total, but the foreman thinks that about 12,000 were procured from each of the above streets. No charge is made against the work for these old city blocks.

It is hardly possible without more complete knowledge of the details of this city work to estimate closely what it should have cost, or rather what it would have cost if done by contract after competitive bidding. It would seem, though, that the following figures should have been ample:

Gravel delivered on street, as per account	$113 40
Blocks purchased	276 00
Hauling blocks to be used by contractor	375 00
Hauling away excavated earth	190 00
800 tons of crushed stone at $1.60 on street (if supplied by contract)	1,280 00
Spreading and grading stone, 2,350 square yards, at 2 cents	47 00
Holidays	40 00
Rolling 2,350 square yards, at 5 cents	117 50
	$2,438 90
Add for miscellaneous items 15 per cent	365 83
Total	$2,804 73

As the city work cost, according to the accounts, $4,768.26, the excessive cost appears to have been $1,963.53, or in other words, the city work cost 67 per cent more than it should have cost.

CONSTRUCTING AND REGULATING DISH GUTTERS ON BEECH STREET, BETWEEN WASHINGTON AND POPLAR STREETS, WEST ROXBURY.

The contract for this work was awarded to Thomas J. Shea on August 2, 1906, and his work was completed on September 12, 1906. His final estimate was as follows:

1,795 square yards preparing site, at 50 cents	$897 50
1,795 square yards granite block laid, at 25 cents	448 75
Total	$1,346 25

The work done by the city is charged in the city ledger as follows:

Labor	$268 57
Holidays	36 00
Steam roller	414 00
Hired teams	1,955 00
Gravel	316 25
Crushed stone	1,511 21
Total	$4,501 03

The city's work consisted of supplying the contractor with paving blocks and gravel and of resurfacing the roadway with macadam. The area of the roadway thus resurfaced was about 8,020 square yards. (Area not stated in the records.)

Crushed Stone.

About nine and one-half tons of the crushed stone was obtained by the city from its Centre street crusher. All the balance used was bought from Thomas F. Welch as follows:

723.35 tons at $1.50 per ton.
212.1 tons at $2 per ton.

There seems to be a discrepancy between the accounts and the statements of the district foreman as to just what these prices covered. The bills upon which Welch was paid indicate that the prices were for the material delivered on the street, while the district foreman states positively that the stone was hauled by teams hired by the city. It will be remembered that in the report upon stone crushers, when

speaking of the Grove street crusher, it was stated that under a contract with Welch, made in 1901, he was to supply crushed stone at this crusher at 90 cents per ton, but that under a new contract, dated October 2, 1906, he was to receive $1.25 per ton at the crusher. This latter contract was made during the time work on Beech street was in progress (the city work was completed October 15, 1906), and this contract price presumably should have applied to the stone used on that street, since the city did the hauling. At the higher prices paid the contractor was doubtless expected, when the order was given, to deliver the stone on the street.

Gravel.

Two hundred and thirty-three double team-loads of gravel were supplied by T. Minton at $1.25 per load, delivered on the street, and twenty double team-loads were supplied by the city from the Mt. Vernon street yard, making in all about 375 cubic yards, charged to the improvement on the city books at $316.25. The gravel was used to make a bed under the gutter paving and to fill the joints between the paving stones. The area of the gutter pavement laid being 1,795 square yards, the computed quantity of gravel required, even if the bed was made four inches deep, did not exceed 290 cubic yards. It appears, therefore, that eighty-five yards more gravel were charged to the street than were needed.

Stone Blocks.

The blocks used for paving the gutters were of the kind called "cobbles." The supply, according to the foreman, came from the following city yards:

From the Massachusetts avenue lot	24,500
From the Dimock street lot	45,500
From the Mt. Vernon street lot	10,500
Total	80,500

The blocks being irregular in size, no reliable computation of the number required for the work can be made. They figure out about forty-seven blocks to the square yard, which is probably reasonable.

Labor.

The total charge for city labor was $304.57, of which $36, or about 12 per cent, was charged to holidays. The only labor required, so far as is known, was for spreading and grading the crushed stone, the cost of which should not have exceeded 2 cents per square yard, or $160 in all.

Teaming.

The charge for hired teams is $1,955. The material hauled consisted of twenty loads of gravel from the Mt. Vernon street yard, the cobble blocks and the crushed stone from the Grove street crusher. The charge is liberal, but probably not excessive.

Rolling.

The charge for rolling is $414. As this work was the repairing of an old macadam road and the average thickness of new stone seems not to have been more than two or three inches, the rolling should not have cost more than 4 cents per square yard, or say $320 for the whole work. The roller was rented from Welch at $12 per day, the city furnishing the fuel. Thirty-four and one-half days' rolling were charged to the work, from which it appears that the average work per day was about 235 square yards, while at least 400 yards per day should have been done on this work. The rate of rent paid per day for the roller was liberal but not excessive, if the time actually at work only was counted, but it seems probable that the roller was idle for a good many days and that this idle time was paid for.

Reasonable Cost of the City Work.

What would have been a reasonable cost for this city work if it had been done by contract after competitive bidding?

The work may be divided into two parts:

First.— Supplies and hauling for the gutter paving as follows:

275 cubic yards of gravel, at $1.20	$330 00
Hauling blocks	750 00
Total	$1,080 00

Second.— The repair of the macadam roadway.

This may be estimated as follows:

950 tons of crushed stone delivered on the street, at $1.60	$1,520 00
Preparing old surface for new stone, 8,020 square yards, at 1½ cents	120 30
Spreading and grading stone, at 2 cents per square yard	160 40
Rolling, at 4 cents per yard	320 80
	$2,121 50
Add for miscellaneous expenses, etc., 15 per cent	318 22
Total	$2,439 72
To this add the cost, as given above, of work and supplies to the contractor's part of the work	1,080 00
Total	$3,519 72
The amount actually charged was	4,501 31
The excess being	$981 31

or nearly 28 per cent.

CONTRACT FOR IMPROVEMENT OF PENFIELD STREET, BETWEEN METCALF STREET AND BIRCH STREET.

The contract for this improvement was let to James W. O'Brien, June 7, 1906. His final estimate bears date July 24, 1906. The work at first contracted for was the setting of edgestones and the excavation and pavement of the gutters (three feet wide each) with granite blocks and some small incidental work. Later, under an extra work order, the grading of the street was added to his contract.

His final estimate was as follows:

Preparing site, 703 square yards, at 50 cents	$351 50
Setting edgestone, 2,083 linear feet, at 21 cents	437 43
Granite block paving, 703 square yards, at 50 cents	351 50
Grading, 983 cubic yards, at 50 cents	491 50
Total	$1,631 93

The necessity for grading down the street seems to have been overlooked when the contract was let, as it is not included in the engineer's preliminary estimate; hence, the order to the contractor to do it as extra work. It appears, further, that no levels or cross-sections were taken to determine the quantity of this extra grading before the work was done, and that

the quantity of excavation was later computed in the general office from an old profile, the correctness of which at the time this work was done was doubtful. It is said that the grade of the street was lowered in some places as much as 3 feet, and that the cut was, at the deepest point, 5 feet deep.

The quantity of excavation allowed the contractor as extra work cannot now be checked up with any accuracy, and the records available do not make it clear how the computation was made. It is said that the area and quantity was figured on the assumption that the street was 40 feet wide, while its actual width is but 35 feet. It is further stated by the executive engineer that the contractor did the grading between curb lines only, the city grading the sidewalks. I am told that Mr. Ewing, of the Good Government Association, claims to have made careful measurements on the ground and to have reported that the excavation did not exceed 538 cubic yards. (The quantity allowed the contractor was 983 cubic yards.)

The contractor is said to have hauled away the excavated material, and if so his price per cubic yard for the extra excavation was not excessive, but he was paid the contract price per square yard for excavating the gutters. This gutter excavation was, in this case, only a part of a large body of excavation, and the whole should have been done at the cubic yard price. In treating it as a separate item and paying for it at 50 cents per square yard the contractor received (assuming that it was one foot deep) $1.50 per cubic yard for it.

City Work.

The city work on this improvement appears in the ledger as follows:

Edgestone	$1,445 83
Hauling	2,546 87
Labor	1,037 61
Holidays	138 77
Crushed stone	1,451 83
Lumber	64 96
Labor by contractor	92 75
Steam roller	276 00
Total	$7,054 62

In this case the city work amounted to just about four times that done by the contractor.

Because of the complications and uncertainties in the records it is not possible satisfactorily to analyze some of the items of the cost of the city work.

Crushed Stone.

The quantity of crushed stone charged to the street was 1,059 tons, as follows:

629.8	tons bought from Welch at Grove street, and presumably hauled by the city, at $1.25	$849 75
389.85	tons crushed stone, presumably delivered on the street by Welch, at $1.50	584 77
39.9	tons dust, presumably delivered by Welch, at $2	79 80
1,059.55	tons, costing	$1,514 32

The area of the macadamized roadway was about 1,910 square yards, and for 6-inch macadam the computed quantity of stone required was about 635 tons, or less than two-thirds of the quantity reported used. There is no record of the use of crushed stone for any other purpose and the inference must be that 464 tons more stone than was used was charged to the work.

Lumber.

It is stated that the change of grade of the street made it necessary to build short stairs in front of one of the houses, and that the lumber charged in the account covers both the material and the labor used for this purpose. It is difficult to understand how the work could have cost so much, but the amount of the item is not important.

Edgestone.

According to the contractor's final estimate 2,083 linear feet of edgestone was set. The records show that there was sent to the street:

From the South End yard	1,871 feet 5 inches.
Austin Ford & Sons furnished on street	99 feet 4 inches.
Total	1,970 feet 9 inches.

In addition two small corners were used.

This is about 100 feet less than the quantity set and paid for. No information as to how this balance was supplied is obtainable. It is not included in the account, which is for:

1,871 feet 5 inches from South End yard, at 70 cents	$1,310 00
2 small corners, at $3.35	6 70
99 feet 4 inches by Austin Ford & Sons, at $1.30	129 13
Total	$1,445 83

Labor.

The charges to labor account are:

Labor	$1,037 61
Holidays	138 77
Total	$1,176 38

No details are at hand, and it is not possible for me to account for this large expenditure for labor. Assuming that it was incurred on account of the macadam road it amounts to about 66 cents per square yard. If, as stated by Mr. Sullivan, the city graded the sidewalks, this fact would account for a small part of the charge. There is also in the account a charge of $92.75 for labor by the contractor, which is said to have been extra compensation for excavating a small quantity of rock encountered in the work.

Hired Teams.

The total amount charged for hired teams and teaming was $2,546.87. It is difficult in the absence of information as to the hauling done to estimate what would have been the reasonable charge for this hauling. The circular edgestone was delivered upon the work by Austin Ford & Sons, the cost of delivery being included in the price paid for the edgestone. The straight edgestone was all, or nearly all, hauled by Gaddis at a cost of $156.87. Deducting this from the total hauling charge we have still $2,390 to account for. The city hauled 679.8 tons of stone from the Grove street crusher, a distance of somewhat less than three miles. This should not have cost more than $755. The blocks were hauled from the Massa-

chusetts avenue lot, a distance of something less than five miles, and the cost should not have exceeded $350. The material excavated from the sidewalks was hauled away by hired teams, but the cost of this should not have exceeded $150. The whole of the hauling done and paid for by the city should not have cost, therefore, more than $1,500, or about $1,100 less than the amount charged.

Holidays.

Excluding the labor done by the contractor, upon which there was no holidays allowed, the allowance for holidays amounted to 11.9 per cent of the whole.

Steam Roller.

This being a new macadam road, with 6 inches of stone, the charge to this account, $276, or nearly 14½ cents per square yard, is nearly three times as much as it should be.

Reasonable Cost of the Work.

The complications connected with this work and the lack of definite information about details makes it difficult to compare the actual with the reasonable cost of the work by items.

We may, however, make a fairly close estimate of what the improvement as a whole should have cost if all the work had been done by contract after competitive bidding. In the estimate that follows it is assumed that the quantity of excavation credited to the contractor was correct, and that the city force excavated the sidewalks:

1,100 cubic yards of excavation, including disposal of material, at 50 cents	$550 00
1,880 feet new edgestone, at 70 cents	1,316 00
Hauling same to street	158 00
99 feet circular edgestone, delivered, at $1.30	128 70
2 small corners, as per account	6 70
2,083 feet edgestone set by contractor, at 21 cents	437 43
Hauling blocks to street	350 00
Laying 703 square yards block pavement, including the gravel (supplied by contractor), at 50 cents	351 50
Rolling the sub-grade, 1,910 square yards, at 1½ cents	28 65
640 tons crushed stone delivered on street, at $1.60	1,024 00

Spreading and grading stone, at 2 cents a square yard	$38 20
Rolling macadam, at 5 cents a square yard	95 50
Lumber and labor, stairs, as charged	64 96
	$4,549 64
Add for miscellaneous and incidentals, 15 per cent	682 44
Total	$5,232 08
The actual cost was	8,686 55
Excess	$3,454 47

or about 66 per cent over reasonable cost.

The actual cost of these three improvements as shown by the city records, and my estimate of what should have been their reasonable cost, including the work done by the contractor, may be summarized as follows:

	Actual Cost.	Estimated Reasonable Cost.
Carolina avenue	$5,768 14	$3,164 05
Beech street	5,847 28	4,865 97
Penfield street	8,686 55	5,232 08
	$20,301 97	$13,262 10

The excess in cost on the three jobs was, therefore, $7,039.87. This excess figures about 53 per cent above the estimated reasonable cost.

It is not contended that my estimates of cost are strictly accurate. Such estimates must always be approximate, and in these cases all the facts necessary to enable me to make a close estimate may not be in my possession. But it can be confidently stated that the work cost the city a great deal more than it should have cost.

The three examples referred to belonged to the class of "Street Improvements," where the whole cost was paid by the city.

Similar conditions were found in the "Making Highways" improvements, though, as a rule, these were somewhat more carefully handled. These improvements were carried out under the provision of chapter 323, Acts of 1891, and chapter 393, Acts of 1896.

Thirty contracts for this class of work were examined. In this class of work, while nearly all the supplies were furnished by the city, a larger part of the work on the street was done by contract, though even in these the contract work averaged only about 31 per cent of the whole.

Of the thirty contracts before me, three awarded in 1906 and eight awarded in 1907 were let to the lowest bidder after advertising for proposals in the regular way, and four in 1907 were let after asking bids from a number of contractors without advertisement. All the others were let without competitive bidding, by authority of the Mayor.

An attempt has been made to compare the prices in the competitive bid contracts with those of the contracts awarded without competition, but, as was to be expected, the differing conditions and requirements under which the different pieces of work were done make comparisons of little value.

Several of these contracts, which appeared from first examination to require more careful investigation, have been looked into in more detail and the results on a few of them are here given briefly, as illustrative of the way the work was conducted. These should not, however, be considered as *average* examples, since the further investigation was made because some features appeared to be, on first examination, anomalous.

In this class of improvements the engineering is charged to the work under the head of "Labor." This was done in order that the full cost of the work shall appear in the amount upon which the assessments were based.

LORRAINE STREET, FROM BELGRADE AVENUE TO COLBERG AVENUE.

Contractor, William L. Dolan.
Date of contract, October 3, 1906.
Date of completion, July 27, 1907.

Amount of final estimate, regular prices	$1,493 69
Extra work, by orders	54 30
Total	$1,547 99

The quantities in the final estimate agree quite closely with those of the engineer's preliminary estimate.

The account for city work is as follows:

Advertising	$7 00
Labor	489 44
Holidays	4 50
Crushed stone	1,199 64
Edgestone	71 48
Flagging	104 00
Granite blocks	278 75
Hired teams	512 50
Total	$2,667 31

There is also incorporated in the account the cost of constructing sidewalks, under a separate contract with Simpson Brothers, amounting to $1,646.91, making the total cost of the improvement as it stands on the books $5,862.12.

The charge for labor is made up of

Engineering	$307 94
Labor, proper	181 50

The only material which, under the terms of the contract, was to be delivered by the city was the paving blocks. Sufficient facts are not available to estimate closely what the hauling of the blocks should reasonably cost, but it should not have exceeded $350. As the charge for hired teams was $512.50 more than $150 is not accounted for.

Crushed Stone.

The charge to this account is for about 750 tons at $1.60, amounting to $1,199.64. The computed quantity required for the work (1,758 square yards 6 inches deep) does not exceed 600 tons. But the crusher and other records show that at least 742 tons were sent to the street. Possibly the macadam was made more than 6 inches thick, but if so the fact is not recorded.

Granite Blocks.

The account for granite blocks is somewhat confused and indefinite.

A large quantity of old blocks had been bought from the Boston Elevated Railroad Company on Columbus avenue, at $10 per thousand. The account seems to have been made

up on the assumption that all the blocks used came from this lot and they were charged up at the price paid. But according to the street inspector the sources of the blocks used were as follows:

Received from Columbus avenue	38 double loads.
Received from Beech and Washington streets	37 double loads.
Received from Massachusetts avenue lot	86 double loads.
Total	161 double loads.

The inspector thinks that about 200 blocks were hauled per load, or 32,000 in all. As only 886 square yards of pavement was laid and as these blocks would not run over 30 to the square yard, not much more than 27,000 blocks should have been required for the work. It is possible that the inspector overestimated the number hauled per load.

All the blocks appear to have been charged up at $10 per thousand, while less than one-fourth of them came from the lot purchased at that price, the balance being presumably city second-hand blocks, for which a price of $20 per thousand seems to be established. If so the charge for blocks should have been increased about $200.

BAKERSFIELD STREET, FROM STOUGHTON TO WILLIS.

Contractor, William J. Fitzgerald.
Date of contract, November 12, 1906.
Date of completion, May 31, 1907.
The contractor's final estimate was:

Regular work at contract prices	$2,389 55
Extra work	575 00
Total	$2,964 55

Of the extra work $565 was for cutting down and removing ten trees. The trees must have been very large and the work difficult to merit so large a compensation.

The quantities of work allowed in the final estimate agreed closely with, but were generally below those of the engineer's preliminary estimate.

Crushed Stone.

According to the contract the contractor was to take the stone he required from the Columbia crusher. It seems, however, that all the required amount could not be procured at that crusher and 156 tons (dust) was taken from the Grove street crusher. The city paid Welch $2 per ton for hauling the latter quantity, so that it cost delivered on the street $3.60 per ton. The city should have charged up to the contractor what it would have cost him to haul this stone from the Columbia crusher, but did not do so. The haul from the Columbia crusher was about one mile and a reasonable charge would have been 30 cents per ton, amounting to $47.

Granite Blocks.

Twenty-six thousand six hundred and thirty-five blocks were charged to the street at $20 per thousand, amounting to $532.70. The area of granite gutter laid was 696 square yards, which at 35 blocks to the yard required 24,300 blocks, leaving an apparent surplus of 2,300 blocks not accounted for. These old blocks varied greatly in size and it is possible, but not likely, that more than 35 were used per square yard.

ROWE STREET, FROM ASHLAND TO SYCAMORE.

This is a 1906 contract.

Contractor, William L. Dolan.

Some irregularities appear in this contract that may be mentioned.

Crushed Stone.

The charge for crushed stone is:

40.77 tons from Centre street crusher, at $1.60	$65 23
466.10 tons bought from Welch, at $1.50	699 16
88.925 tons bought from Welch, at $2	177 85
Total	$942 24

The contract specified that the contractor was to take all the stone required from the Centre street crusher. Presumably a supply was not on hand there when the contractor wanted it.

Welch delivered the stone purchased from him, and the contractor was relieved from hauling that quantity about two miles. The city should have charged the contractor a reasonable sum for thus delivering the stone on the street. The cost of delivery from the Centre street crusher would have been about 50 cents per ton, and on the 555 tons delivered by Welch the rebate would have been $277.

Granite Blocks.

The account for granite blocks is as follows:

225 blocks from District No. 8, at 7 cents	$17 85
4,400 blocks delivered on street, at 2.3 cents	101 20
5,870 blocks, probably from Columbus avenue, at 1 cent	58 70
10,495 blocks, costing	$177 75

The area of the paved gutters was 287 square yards, and, allowing 35 to the square yard, only 8,610 blocks should have been required. If so the surplus charged to the improvement was 1,885 blocks.

Hired Teams.

Charge, $200. The city was to supply the blocks to the contractor delivered on the street. If 5,870 blocks were hauled from Columbus avenue, as seems probable, and 225 were hauled from District No. 8, the cost of hauling should not have exceeded $100. There was apparently no other hauling done. It is said that a part of the hauling for a repair contract held by Dolan at the same time, on Ashland street, was by mistake charged to Rowe street, but there is no positive evidence.

Rolling.

Although the contractor was to do the rolling at his expense, it appears that a roller was hired by the city from Welch, and the cost ($78) charged to the improvement. The city should have charged this to the contractor, but did not.

Without taking up more of these contracts in detail some apparent errors and discrepancies occurring in others may be noted. On the Bennington street contract (1906) there is

charged against the improvement a court judgment for $2,439.31, presumably for damages to property, but the basis of the judgment has not been looked up from the legal records.

On Milwood street (1906) only about one-half of the number of granite blocks required are charged to the improvement. It is possible that some blocks were already on the ground, but no definite information can be obtained.

The charge for labor, exclusive of engineering, was $216, which seems excessive. The contract was let on October 3, 1906, and the work was completed April 18, 1907; but the city labor force appears to have been at work on the street from August 17, 1906, until December 26, 1907. There is no record of what it was doing.

The contract provides that all hauling shall be done by the contractor, but there are, nevertheless, teaming charges amoun[redacted] to $214.49 which are unaccounted for, except that the contractor's final estimate is charged with $12.87 for hauling crushed stone.

Artificial stone sidewalks were constructed on this street under contract with Simpson Brothers, and the city labor and teaming may relate partly to that contract, as the city charges do not appear to be separated on the two contracts.

On Roseland street, Dorchester avenue to Samoset street, some of the quantities in the final estimate over-run considerably those of the preliminary estimate. It is explained that this is due to work done in connection with this improvement on Dorchester avenue. Roseland being an assessment street, this would appear to be a questionable and dangerous procedure, unless the work on Dorchester avenue was clearly necessary for properly connecting up the streets.

GENERAL CONCLUSIONS.

The study in more or less detail of nearly 200 improvements belonging to the two classes "Street Improvements" and "Making Highways" has led me to the following general conclusions:

1. Notwithstanding that the great majority of the contracts for such work were awarded without competitive bidding the prices paid were, with few exceptions, reasonable.

2. The quantities of work for which the contractor was paid agree closely, as a rule, with the quantities previously estimated to be done by the Engineering Department. But there are many exceptions. Thus, on Congress street, Fort Point Channel to New York, New Haven & Hartford Railroad, the estimated quantity of granite block pavement to be done was 6,970 square yards, while the area paid for was 9,172 square yards. Taking the length and breadth of the street paved the area figures about 6,700 square yards, but to this should be added the area of intersecting streets back to the house line of Congress street, which were doubtless paved, and the paving of connections with intersecting streets. On Washington street, between Arnold and Ball streets, the estimated area of granite block paving was 600 square yards, while 1,040 square yards was paid for. On Huntington avenue, between Gainsboro and Hemenway streets, the estimated area of granite block paving was 1,200 square yards, while 1,725 square yards was paid for. Many other instances might be given, but there is no evidence in those examined that the contractor was paid for more work than he actually performed. The engineer's preliminary estimates seem rather to have left out a part of the work to be done.

3. The engineer's estimates of the *cost* of the work done by contract, where given, also agree closely, in most cases, with the contractor's final estimate.

4. The allowance to contractors for extra work are, in most cases, relatively small and unimportant.

5. In so far as can now be ascertained the work of the contractors was properly done.

6. The limits of the contractor's work and the quantity of work to be done by him were often extended by the department without the formality of a supplementary contract and sometimes without formal written orders. Examples are:

Columbus avenue, between Washington street and Walnut avenue (1906). Contract was for improving north side of street, but was extended to cover the south side from Dixwell street to Walnut avenue. The quantity of gutter paving was thus increased over 50 per cent.

Howland street, between Humboldt and Elm Hill avenues. Extended 200 feet beyond Humboldt avenue and work done on Humboldt and Elm Hill avenues. The quantity of granite block paving was thus increased from 800 to 1,227 square yards.

7. In order to include extra work done by the contractor the actual quantities were in a number of cases changed so as to equate the final estimates. The case of Carolina avenue has already been mentioned. Other examples are:

Waumbeck street, Warren to Wabeno. The records show that 700 square yards of granite block were laid, whereas the actual area was 684 square yards. Gleason street, between Harvard and Bradshaw (1906), the area of granite block actually laid was 654 square yards, while the records show 768 square yards. Boston street, between Washburn and Dorset streets (1907), area of granite block pavement shown by the records, 2,655 square yards; actual area laid, 2,592 square yards.

In all the cases examined these changes were made in order that the amount justly due the contractor might be paid without introducing into the final estimate small items not provided for in the contract. The objections to this procedure have already been stated.

8. There does not appear to have been any notable favoritism in awarding contracts to certain contractors. Out of nearly 200 such contracts of the two classes, executed in 1906 and 1907, examined by me, I find that two contractors each had 10 contracts, averaging in magnitude less than $1,500 each, at reasonable prices. Two others had eight and four others five contracts each. In all, the 197 contracts were divided among 69 contractors. A hasty study of the prices does not indicate that those paid to any one contractor averaged higher than those paid to others.

9. The cost of that part of the work done by the city usually exceeded, often very greatly, the engineer's estimates. A few illustrations are given:

	Engineer's Estimate.	Final Cost.
Bradshaw, Esmond to Charlotte, 1906	$826 00	$1,400 00
C street	23,700 00	39,708 00
Oakridge, between Morton and Codman	3,800 00	4,778 00

10. The cost of the work done by the city was in a great majority of the cases excessive. I think it a very conservative statement to say that the average cost of this city work was 35 per cent higher than it would have been if the whole work had been done under contract, based upon competitive bids.

11. The charges for the items of city labor and for hired teams are generally excessive. These items have been analyzed in only a few cases, as it is almost impossible to get satisfactory data.

(*a.*) After deducting the cost of engineering and inspection (where these are charged) the remaining labor charges are so high that it is difficult to account for them: Thus, on the Congress street contract the labor charges, exclusive of engineering and inspection, amount to nearly $900. One item of this is $345 for stonecutters, who were said to have been employed to redress the joints of the edgestone before it was reset. If so the cost figures nearly 14 cents per linear foot for all the edgestones set, which is about three times what such work should cost.

On Essex street, Charlestown, 1906, the labor charge, including holidays, is $832.84, of which $75 is charged to holidays and $274.50 to engineering. Among the employments designated for the balance of the pay roll are sub-foremen, rammers, pavers, helpers, carpenters, masons, stonecutters and laborers, but what all these could have been engaged upon is not evident.

The city labor on Waltham street, Washington to Tremont (1907), figures 27½ cents per square yard of the whole area improved.

(*b.*) The charges for hauling, usually by hired teams, are more generally excessive than the labor charge, and while it

is impossible to verify them or classify them to the different items of work, we may arrive at fair conclusions by considering their magnitude compared with the whole work. On the Gleason street contract, Harvard to Bradshaw (1906), the charge for hired teams figures over 27 cents per square yard of the whole improvement. On the contract for Warren street, Roxbury (1906), the hired teams figure over 51 cents per square yard for the whole area of the improvement. On Carolina avenue (1906) teaming amounts to over 40 cents per square yard of the whole improvement. It is also to be said about these charges for hauling that none appear on a number of contracts where there is evidence that there was more or less city hauling to be done.

12. *Holidays.*— The allowance for holiday time on individual contracts of this class seems to bear little relation to the total labor charge. On some "Street Improvements" it is relatively very large, running from 15 per cent to 20 per cent of the labor charge. On the contract for paving and regulating the north side of Columbus avenue, between Washington street and Walnut avenue (1906), the charges are:

Labor	$2,973 66
Holidays	438 82
or 14¾ per cent.	

In other cases the holiday charge is very small, as low as 2 per cent, while on quite a number no holiday allowance appears. On one hundred "Street Improvements" taken at random the average holiday allowance is about 8.8 per cent, which is probably about what is provided for by law, but the allowance on individual improvements seems to have been made at random.

The allowance of holiday time in the labor accounts on "Making Highways" is very small. Less than half of the accounts contain any item for holidays. On thirty contracts where the labor charges, including engineering, aggregate about $11,000, the total charge for holidays is $91.25, or less than 1 per cent. It seems probable that on these assessment streets holiday time was charged to the work.

13. *Rolling by City Force.*— The great majority of these

improvements involve no macadam work, or only slight repairs, and a steam roller was not needed. The smaller areas are generally rolled with a horse-power roller, the cost being charged to hired teams. The charges for rolling with steam roller are nearly always excessive, frequently amounting to between fifteen and twenty cents per square yard of the surface rolled. On repair work of the general character of most of these improvements the cost of rolling should not exceed 6 per cent per square yard.

In "Making Highways" contracts the rolling was done by the contractor, the cost being included in his price for macadam surface. But in a number of cases the contractor hired the city roller, the city charging him for its use, and also charging the improvement for such use. In two cases there is, in the city account of the cost of the work, an item for steam roller, but no corresponding charge was made against the contractor. In the aggregate, the city charges against contractors for use of rollers was $765, while the improvements were charged $925 for that item.

14. The method of keeping records and accounts in the Street Department is so defective that it is not possible to analyze and to verify satisfactorily the cost of the city work. To do this requires an itemized cost account, *i. e.*, the cost of the several kinds of work that together make up the whole improvement. Our knowledge of the cost of street work is based upon what experience has taught us of the cost of the several items or kinds of work that make up an improvement as a whole, and in the absence of this information we cannot properly locate any apparent excess in the whole cost of the improvement.

15. The city records and accounts sometimes include work not embraced in the improvements under which the cost is charged, or include in one account the cost of work under two separate contracts, as well as items of extra work not embraced in the original contracts. Thus, under the account for the contract for paving and regulating Blue Hill avenue, between Stafford and Woodville streets, is included a part of the work done on the same street between West Cottage and Brookford streets, the latter done by the

same contractor under a contract dated July 12, 1907. These additional quantities of work are entered under the item "paving," although there was included the setting of 773 linear feet of edgestone, as well as a large quantity of granite block paving not embraced in either contract nor covered by recorded orders for extra work.

16. The city records and accounts do not appear to be complete and accurate.

(*a.*) According to the wording of a number of the contracts the city was to have furnished, delivered on the street, certain of the supplies used. This involved hauling, but no charge for such hauling appears in the accounts.

Example.— Contract for Oak street, between Washington and Albany. The contract provides that the city shall furnish paving blocks, flagging and edgestones on line of work. The following material was thus supplied and charged to the work:

Edgestone	$121 26, about 295 feet.
Flagging	268 66, about 380 feet.

But there is no charge in the accounts for hauling these supplies.

Similar examples are Dorchester street, near West First (1907), Harrison avenue, between Bristol and Dover streets (1907), Rochester street, between Harrison avenue and Albany (1907). In other cases where there is a charge for teaming it appears to be inadequate for the hauling presumably done.

(*b.*) The quantities of supplies reported as used, furnished by the city, cannot in a number of cases be verified, and they differ from the records at the supply yards and those kept in the engineer's office. The discrepancies are usually, however, small, and are important only as illustrating the lax methods of keeping track of the city supplies. Thus, attention was called in the detailed account of Penfield street to the fact that over 100 linear feet of apparently new edgestone, the setting of which was paid for, is not charged up in the final account.

In the contract for paving and regulating Congress street (1906) the final estimate includes 6,062 square yards of concrete base, six inches thick, which the specifications require

to be made of one part cement, three sand and seven crushed stone. This would require nearly one barrel of cement to each cubic yard of concrete or one barrel of cement to each six square yards of base, or over 1,100 barrels of cement in all. Only 873 barrels are charged to the work. If the account is correct and the concrete was made six inches thick, as required, it could not have been made according to the specifications.

In "Street Improvement" work the value of the old granite blocks used for gutter and other paving is not charged to the work. Presumably this is because their value was not credited to the street from which they were taken up, and no charge made for them to stock at the yards where they were stored. While this practice does not affect the general balance in the accounts of the department, it does affect the accounts with individual streets. It was often, if not usually, found that the records of city supplies were incomplete or erroneous. Where, for instance, supplies were sent from storage yards to a street there is often no record on the yard books of the sending out of material; its receipt on the street is often not noted, recorded or reported, and no return of it made to the accounting branch of the department. In many cases where some attempt at recording is made, the records in the yard books, the inspector's notes, the figures reported to (or at least now found in) the engineer's office and the ledger entries all disagree, and it seems impossible in a great many instances to ascertain what were the true quantities.

17. For the purpose of getting average results the city charges on 100 "Street Improvements" were summed up and classified. The total amounted to $283,392. Of this sum $35,759, or 12.6 per cent, was for labor; $3,142, or 8.8 per cent, was allowance for holidays and $52,987, or 18⅔ per cent, was for teaming.

The total cost of this class of improvements in 1906, according to the published report of the department, was $692,546. Estimates of what this work would have cost had it all been done under contracts awarded after competitive bidding must necessarily be little more than guesses, but in my opinion it is very conservative to say that it would not have

cost more than 80 per cent of what it actually did cost. A saving of 20 per cent would have amounted to $138,509 in that year.

ACCOUNTING FOR OLD MATERIAL.

There seems to be a source of confusion and indefiniteness in the city accounts, caused by the method in use for accounting for old or second-hand supplies, particularly granite blocks. The general procedure with reference to these old blocks seems to be as follows: When an old granite pavement is taken up and relaid the old blocks taken up are hauled and stored in one of the city yards. Their value is not credited to the street from which they are taken nor charged to stock in the yard. Nor are they charged up to "Street Improvement" work when reused on that class of improvements. But when used on assessment streets these old blocks are charged up to the improvement at the uniform price of $20 per thousand at the yard.

When later a part, say one-half, of the cost of the improvement is assessed against the property owners and collected the city thus collects pay for material which, so far as the books show, cost it nothing. To illustrate: A certain street when paved years ago had charged to it the full cost of the new granite blocks used; when later these blocks were taken up for the purpose of repaving the street they were stored at a yard, no note being taken in the city accounts of their value. Later still the same blocks are used for an assessment improvement, to which they are charged at, say, $20 per thousand. A part of this charge is assessed against the property owners, and returns to the city treasury, where it must appear as an unbalanced account. The city originally paid, say, $70 per thousand for them and charged them off to the original improvement at the same price. It now charges them to another street at $20 per thousand, thus crediting itself in the end at $90 per thousand, whereas they were only charged to the city at $70 per thousand. The effect is to artificially swell the income, or, what amounts to the same thing, apparently (though falsely) reduce the expenditures of the department.

I find that in thirty-two of these assessment improvements carried out in 1906 and 1907 about 16,000 square yards of granite block paving was used. The number of granite blocks required was probably about 480,000. In a few cases new blocks were used, but it is probable that 450,000 of the lot were old blocks, which if charged out at $20 per thousand amounts to $9,000. If 40 per cent of the cost of the improvement is assessed against the property owners the city will eventually collect $3,600, which, in the city accounts, will be a credit without any corresponding debit. If, as sometimes occurred, the city purchased the old blocks this illustration would not be strictly accurate since these blocks would be charged to the improvement at the purchase price. We have already noted that the city thus purchased a large number of old blocks at $10 per thousand.

The last statement suggests another observation. The justice, and possibly the legality, of charging certain supplies of the same kind and quality (and at the same time) to different assessment improvements at different prices, may be questioned, though the sums involved may be too small to warrant a property owner in taking action; but in assessment work it is important to follow correct and legal principles. More or less differences in cost of supplies are unavoidable on such work, but some system should be worked out and applied that will not be faulty in principle.

RECOMMENDATIONS.

I have only a few general recommendations to make in regard to the conduct of street paving and repair work, but these I regard as fundamental, and as absolutely essential in any adequate reorganization of that work in Boston.

First.—The form of contract and specifications for street pavement and repair work should be thoroughly revised. I shall take up this matter in detail later and only mention it here in its logical sequence as a part of the general scheme to be recommended.

Second.—Contracts for street work should be awarded only after public competitive bids have been obtained in the way

prescribed by law, and only to the lowest responsible and competent bidder. The necessity for this is obvious, and no explanation or argument is called for.

Third.—All street construction work, and all street repair work where possible, including the furnishing of all supplies, should be done by contract only. In other words, when a street improvement is to be carried out a contract for making that improvement should be made, and that contract should include the furnishing of all the supplies of whatever character required, as well as the doing of the actual work complete in every detail, excepting, of course, the engineering and inspecting.

It might perhaps be sufficient to say that this is the present practice in the great majority of American cities, its practicability and superiority having been established by long experience.

The matter is of such great importance, however, as to merit further consideration in some detail here.

The question whether it is better for a municipality to do all or a part of its public work by the "direct" method, that is, without the employment of contractors, has not only been widely discussed, but we now have a large amount of data, the result of experience, bearing upon the subject.

It is unnecessary to discuss the broad question here, except in so far as it may have a direct bearing upon the situation in Boston.

1. The claim that a municipality can execute its public works at an actual cost as low as the same work can be done by a contractor, and thus save the profit that the contractor is entitled to make, may be true as an abstract theory, but experience has shown that it is not generally true in practice. It has in many cases been found true in isolated instances, or for short periods of time, but when the practice has been continued for any considerable period it is almost invariably the case that direct work becomes more expensive than contract work. The reasons for this are not difficult to find.

Municipal officers are generally so fully occupied by the executive duties which constitute their normal work that they cannot devote the time and attention to the actual practical

conduct of street work that is absolutely required to secure economical results. Their departments are usually organized for supervisory, technical and clerical work, and not for the actual control and execution of the work on the streets. They are not usually equipped with the practical experience necessary for the economical handling of the field work of construction. The very large amount of such work in progress simultaneously in any city makes it impossible for them to give to each particular improvement the personal care and attention necessary to secure the best results. Nor can they be expected to have the same personal interest in doing the work economically as has the contractor. Furthermore, they are subject to well known and practically unavoidable conditions which, if all other things were equal, would place them at a disadvantage compared with a contractor. Labor employed by the municipality is not only paid higher wages as a rule, but is less efficient than that employed by private persons and corporations.

On the other hand the contractor usually devotes his whole time and attention to the particular work upon which he is engaged; he has been trained by experience in that kind of work; he will, as a rule, have but a few improvements under way at the same time and can give each the careful supervision and attention to details that is necessary to insure the most economical handling of the work, and his pecuniary interest in the outcome impels him to do the work as cheaply as possible.

Under such conditions it could not be expected that the city officials would be able to compete successfully with the contractor in the economical handling of public works.

2. The claim that public work executed directly by the municipality is more certain to be of good quality than if done by contract is not well founded.

It is a plausible proposition that municipal officers, having no personal financial interest in the results, will be actuated only by the desire to secure to the city the best quality of work, but experience has not shown it to be true. There are motives other than the mere saving of money that may, and as a rule do, influence city officials to cut down the cost of

public work done under their direct supervision to the lowest figure, with possible detriment to the quality of the work done. Public opinion, often unreasonable, demands in such cases that a good showing shall be made, and does not stop to consider that quality is of more importance than low first cost; and since it is hardly ever possible for the municipality to carry out the work as well and at the same time more cheaply than prevailing contract prices, there is a very strong temptation to vindicate the policy adopted even at the expense of the quality of the work done. A laudable ambition to save money for the city may influence them to be less scrupulous in enforcing strict compliance with details they may consider not very important than they would be if the work were being done by a contractor.

I have had good opportunity to observe in many cities the comparative quality of work done by the municipality direct and by contract, and I do not hesitate to say that, as a rule, the former is not usually superior to the latter.

3. The claim that it is either better or more economical for the municipality to purchase and furnish to contractors the supplies required for public work is not supported by the facts. It is often argued that a city can, by purchasing supplies in large quantities, obtain them not only at lower prices but of better and more uniform quality than can the contractor who is compelled to buy on the market what may be needed for each piece of work. The argument is sound, but practical experience does not, as a rule, support it.

It has doubtless developed in your investigations that the City of Boston has been and is paying more for the street supplies it purchases than is paid for the same materials by responsible contractors. Other cities where the experiment has been tried have often had the same experience. It is not necessary for our purpose to discuss the reasons for this, many of which are obvious. Nor is it true as a rule that a better quality of supplies is secured when purchased by the city than when they are purchased by contractors under proper city specifications and subjected to proper inspection.

4. The claim sometimes made that by doing its work directly the municipality can so provide for the employment and con-

trol of labor as to benefit the city at large, or its dependent citizens, is fallacious in practice. When public work is to be done the necessary labor must be employed either by the city or by the contractor. For doing the same work the city can use no more labor than the contractor if the labor employed by each is equally efficient and equally well directed. If economical results are to be obtained, equal care and discrimination must be exercised in securing labor by the one as by the other. If it be said that the city may so manage the labor supply as to afford employment to indigent or inefficient laborers (whom no contractor would employ), who would otherwise have to be aided from the city treasury, it may be answered that the city can no more afford to employ that class of labor than the contractor, and that it is better and cheaper in the end to pension or otherwise care for the disabled or inefficient. Laborers belonging to these classes do not earn the wages paid them, and a few of them scattered among strong and able workmen have a demoralizing effect upon the whole body by setting a low standard of accomplishment.

It is hardly necessary to say that the real motive at the bottom of all arguments for the direct employment of labor by the city is, usually, the securing and controlling of political support. It being notorious that municipalities pay higher wages and get less efficient labor than private employees, these two conditions alone furnish a sufficient reason why cities should not employ labor on the large scale necessary to do work by the direct method.

The advantages of carrying out all municipal public work by contract may be briefly summarized:

1. Under properly prepared contracts and specifications stating fully and explicitly the object to be accomplished, the character and quality of the materials to be used, and the manner in which the work is to be done, followed by proper supervision and inspection of the work as it progresses, municipal work may be carried out at least as honestly and well as regards the quality of the work secured by the contract as by the direct method. If it be said that municipal officers and employees are liable to be corruptly influenced by con-

tractors to permit improper work, it may be replied that the same employees, if disposed to corrupt conduct, would find equally as good opportunities to exercise their inclination if in charge of doing the work for the city.

2. In the great majority of cases municipal public work can be done at less cost by the contract than by the direct method.

3. Where the work is done by contract the municipal officers are relieved of a very large amount of labor and responsibility that devolves upon them under the direct method, and are thus able to devote their time to the more appropriate and legitimate work of their positions. When the preliminary preparations are completed and a contract awarded their sole further duty is to see that the contractor's work is properly done, to measure up the work, and to prepare the contractor's final estimate. They are relieved entirely of the purchase and distribution of supplies, of the employment and direction of labor, of the actual direction of work upon the streets, of the preparation of pay rolls, and of the recording and distribution of accounts for labor. There is good reason to believe that the present lax methods of conducting street work in Boston are attributable in a considerable degree to the fact that the department is overburdened with a mass of details which it is not properly organized to handle efficiently.

The practical operation of a system of doing all street work by contract is comparatively simple, particularly as we have the experience of the great majority of American cities to guide us. The contractor supplies all the materials needed and does all the work of making the improvement complete, and is paid for the work done at the unit prices stipulated in the contract. These prices, as proposed by him and incorporated in the contract, should cover every possible detail of the work that can be foreseen. Unforeseen or contingent work may be provided for in supplementary contracts or by orders for extra work, which should in every case be in writing and state the prices to be paid, or at least stipulate how the compensation is to be determined.

It is, of course, impossible to provide for doing *all* street

work by contract, as, for instance, minor repairs to macadam roads. In most cities it is deemed best to keep a small organized force under the street department for such work. But the greater part of even this class of work might better be done by contract. If, for instance, the macadam surface of a street needs repair a contract can be made providing a fair compensation for the work done, to be based upon the quantity of crushed stone used, the price paid per ton or per cubic yard to cover the work of preparing the old surface and placing and rolling the new stone. Other pavements may be repaired by contract at a price per square yard of the surface repaired. There would still, however, be work for a small repair force, but its operations would be upon a scale so small as to be a negligible quantity compared with the large volume of work now done by the city forces in Boston.

The substitution of contracts for as large a part as possible of the street work in Boston would at once reduce very greatly the work and responsibilty of the street and engineering departments, enabling them to dispense with a large number of present employees. It would provide an effective remedy for, or rather would remove all occasion for the careless and irregular methods of recording and accounting for supplies and labor in the department, and would greatly reduce the work of the bookkeeping department. What is of more importance, it would, in my opinion, result in greatly reducing the expenses and expenditures of the department. Not only would the actual street work be done at a lower first cost, but the incidental expenses, such as maintaining expensive storage yards for supplies, and the interest accruing on large sums paid for such supplies in advance of their use, would be avoided.

METHODS OF DOING WORK IN OTHER CITIES.

Referring to the statement made in the preceding recommendations, that street work is done largely by contract in the great majority of American cities, I was requested by your Board for some further information on that point.

I, therefore, prepared and sent out to the city engineers of nearly all the cities in the United States having a popula-

tion of 30,000 and over a circular letter of inquiry, inclosing a blank form with a number of questions to which answers were requested. In addition, the letter was sent to all New England cities having a population of 10,000 and over. In all about 200 of these letters were sent out. One hundred and eleven replies were received, but some of the larger cities of the country failed to reply.

The replies have been tabulated and classified, and a synopsis of them prepared. The results may be briefly stated.

The very general prevalence in the New England cities of the practice of doing all kinds of street work by city forces is the most striking fact revealed by the inquiry.

Out of the 39 New England cities reporting, it appears that street and pavement new construction work is done exclusively by city forces in 15 of them, exclusively by contract in only 5, and partly by each method in 19. All other street work is done in these New England cities almost exclusively by city forces. In nearly all of these cities an organized force is maintained for doing street work.

Outside of New England the custom of doing street work by contract strongly prevails. Thus, in 72 of the cities reporting street and pavement new construction work, as well as reconstruction work, is almost exclusively carried out by the contract method. Only 3, Minneapolis, Minn.; Wilmington, Del.; and Savannah, Ga., do new construction work exclusively, and only 6 others attempt to do such work partly with city forces. The more extensive repair work is also done in nearly half these cities by the contract method. But minor repair and maintenance work is done almost exclusively by city forces, except where special kinds of pavement are maintained by the original contractor under his guaranty, or under repair contracts applying to such pavements only. Quite a number of cities have erected municipal asphalt repair plants and are now repairing their asphalt pavements upon which the guaranty has expired with city forces. Upon the whole, however, the replies show that a very small percentage of street work is done by the city forces direct in the cities outside of New England.

It appears that with a few notable exceptions the *larger* cities do the great bulk of their street work by contract, while city force work is mostly confined to the smaller cities. This tendency is not difficult to explain. In the smaller cities the conditions, both physical and political, are more favorable to the employment of the city force method. In the large cities not only is the problem of properly organizing and managing a force adequate for the construction and repair of the streets more difficult, because of the magnitude and complexity of the work, but it is more nearly impossible to exclude politics, favoritism and graft from an organized city force. This fact is frequently mentioned in the replies under the head of remarks.

It is fair to say that in the three large cities named, where the city-force method is being applied to new construction work, the results are very favorably spoken of in the replies. It must be remembered, however, that the adoption of this plan is in every case very recent, and it must be considered as yet experimental.

CHAPTER III.

RECORDING AND ACCOUNTING FOR SUPPLIES AND LABOR IN THE PAVING DIVISION OF THE STREET DEPARTMENT.

It became very evident from our examinations into the street paving work of the Street Department that the methods and practice now in use for recording and accounting for supplies and labor employed on the streets were careless and defeective. I was asked to suggest a system which, if intelligently applied and enforced, would remedy the existing defects.

It is difficult without a very intimate knowledge of all the conditions and details of the work of the department to frame a system of records, reports and checks that shall be applicable without more or less modification and adjustment, but the principles and the general practice that should be followed may be outlined and their application to Boston suggested.

As a rule the larger and more able contractors of the country have successfully applied such a general system to their business, though the details may differ quite widely with the character of the work. Very few cities have, however, given careful attention to the matter, and I have found practically no satisfactory models to follow in municipal business. This is largely due to the fact that most cities conduct all their construction and much of their repair work under the contract plan, and have, therefore, little occasion to employ elaborate systems for work done directly by the municipality.

The plan of furnishing a great part of the supplies used, and of doing much of the street and other work by the direct system, as is done in Boston, is, in my opinion, uneconomical and wrong, and I have already outlined the reasons for this

conclusion. What is here said is, however, intended to apply to the present system of conducting public work in Boston.

The first requisite in any system of recording and accounting for supplies and labor is that it shall be as simple as possible. If elaborate and complicated it will be difficult to apply and enforce. City employees are not always intelligent and competent, nor do they usually take kindly to methods of conducting business that are cumbrous and involve care, accuracy and diligence. Furthermore, the actual labor and attention required to operate such a system is very considerable, and the necessary quality and quantity of assistance is often not employed. This is particularly true of the "outside" employees, that is, those engaged directly upon the field work, who usually are, or should be, quite fully occupied with work of an executive or supervisory character. For this reason the work of these outside employees should be simplified as much as possible and their duties largely confined to the making of actual records, leaving the collation, computation and classification of these records to the office or clerical force, which should, of course, be properly organized to do this part of the work. For the same reason the multiplication of forms to be filled out, and the duplication of work by different persons, except in so far as it may be necessary for complete record or for verification and checking, should be studiously avoided.

After framing, in outline, a proper system to be employed the second stage is to design and prepare a system of blank forms, with instructions for their use. These should constitute the bones or framework of the system, around which the details of operation will be built.

To comply with the first requirement of simplicity, these blank forms should be as few in number as practicable, and while sufficient to form a complete record, with adequate checks, they should be designed so as to require the minimum amount of labor, and should be so plain and definite that employees of ordinary intelligence will have no difficulty in dealing with them.

I have attempted to get up a set of such blank forms for the

street construction and reconstruction departments and will make them the basis of what I have to say on the subject. There are seven of these, and they are attached hereto and numbered consecutively. As remarked above, they may not be found adapted in every detail to the Boston methods and conditions, but the general plan should be adequate and satisfactory.

It is assumed that the work will be in general charge of the chief engineer of the department (herein called the general office), that the immediate direction of and responsibility for the work will devolve upon an assistant engineer, with such receivers of supplies, timekeepers and inspectors as may be necessary, reporting directly to him.

In inaugurating any given improvement the preliminary procedure will, of course, be a general plan for the work and an estimate of its cost, and later a schedule of the supplies that will be required, prepared either by the chief engineer or his assistants. When the work is to be commenced provision must be made for the supplies required, whether they are already in the possession of the city or are to be purchased for the work. Arrangement must then be made for the delivery to the work of these supplies. It is at this point that the system recommended comes into operation.

A number of the blank forms submitted have been partly filled in to illustrate their use. In such cases the printed part of the form is shown in print, while the illustrative filling-in is in script.

FORM 1.— REQUISITION FOR SUPPLIES.

This document when filled out and issued becomes the basis for the supply accounts for the work, and its serial number, appearing upon the subsequent records and accounts, identifies the particular improvement, to which the supplies are to be charged. Several such requisitions will usually be issued for the same improvement, but all will be on record in the general office, and there can be no confusion as to the particular work to which their serial numbers refer.

Requisition

Form 1

No. 24

May 4th 1908

To Wm Page

Foreman Yard 7

Deliver to Chas Warren Asst Eng

At Grove St

For Pave & Reg

Edgestone	ft.	420
Gr. blocks #2	No.	4230

Begin Delivery May 7th 1908

Complete Delivery May 15th 1908

John Swaine

Requisition for Supplies

Form 1

Street Department No. 24

Office of City Engineer, May 4th 1908

To Wm Page

Foreman Yard 7

You are directed to deliver to Chas Warren Asst Engineer

At Grove St bet Elm and Chestnut Streets

For Paving and Regulating

The following Supplies:-

Description		Quantity
Edgestone	Lin Ft.	420
Granite blocks #2	No.	4230

Delivery to begin May 7th 1908 and to be completed May 15th 1908 unless otherwise directed by the Assistant Engineer in charge of the work

The quantities named above are approximate and may be changed by direction of the Assistant Engineer in charge.

As soon as the requisition is filled, report to the undersigned on Form No. 6 the quantity and value of the supplies delivered

John Swaine
City Engineer

Sheet 41

One such requsition would be directed to the foreman at a storage yard where part of the supplies, such as edgestones, flagging, granite blocks, etc., are stored; another to the weigher or inspector at a crusher where the crushed stone is to be procured, another to the contractor who supplies brick, etc.

These requisitions should be made to cover all the supplies used. If the need arises for other kinds of supplies not embraced in requisition already issued, additional requisitions may be issued during the progress of the work; but where it is found that the *quantities* named in any requisition must be increased or decreased the custodians of the supplies are authorized to change the quantity by direction of the assistant engineer in charge. This will not lead to confusion, as all the supplies must be subsequently accounted for.

Copies of all requisitions for any particular work should be supplied to the assistant engineer in charge, for his information, and so that he may modify the quantities as developments may require.

FORM 2.— DELIVERY TICKET AND STUB.

These are intended to cover the conveyance of the supplies from the custodian (upon whom requisition has made been) to the work, where they will be received by a receiver. This form is purposely made as simple as possible consistent with efficiency and the making of a complete record. Their use will be apparent without much explanation. They have printed serial numbers, identical on ticket and stub, and should be issued in bound books. For every load of material sent out one of these tickets with its retained stub will be filled out, and the ticket torn off and given to the teamster. Upon arrival at the work the teamster must present this ticket, with his load, to the receiver on the work, who, if he finds the load to agree with the ticket, will receipt it, and it is then to be returned to the custodian as the teamster's voucher for the labor performed. Failure to return these tickets will subject the owner of the team to a suitable fine. The receipt of the load upon the street is indicated by the

punch-mark of the receiver in the proper place. If the punch is not used the signature may be written directly below the line "Received as represented."

The use of the ordinary conductor's punch wherever practicable, in place of written signatures, is advocated because it is not only more rapid and convenient, but it is less likely to be counterfeited, changed or erased, than the ordinary signature. Where the use of these punches is indicated in these forms the persons authorized to use them should each be supplied with a punch making a distinctive punch-mark.

Form 2. 349		Form 2. 349 Delivery Ticket
Requisition No. 24		Requisition No. 24
Date May 7th 1908		Date May 7th 1908
Teamster J. Smith		Teamster J. Smith
Supplies:-		Supplies:-
150 - #2 Granite blocks		150 - #2 Granite blocks
Ticket Returned ✓		Received as Represented ◊

Delivery Ticket & Stub

The custodian will promptly compare and check off on the stubs all returned tickets, will post his supply books from the stubs, and when the delivery is completed, will forward to the general office *all* the returned delivery tickets for that delivery, with his report (Form 6).

These tickets, with very slight modifications in their application, may be used for the transfer of all supplies, including the return of unused supplies to storage yards, etc.

Upon the failure of any ticket to be returned promptly the custodian should inquire of the receiver whether he receipted it, and should hold the team owner responsible for any loss.

The checking up of the time and operation of the teams is provided for in another form (Form 7).

Form 3 See instructions on back

Receivers Record

May 7th 1908

Received this day the following supplies for Grove Street

Delivery Ticket Number	Kind of Supplies	Quantity
349	#2 Granite blocks	150

Signature B. Peters
Receiver

INSTRUCTIONS:- (to be printed on back)

Enter each load of supplies on this blank before punching receipt on delivery ticket. At the end of each day make up from these records report to Assistant Engineer and then forword all these orignal sheets for the day to the Chief Engineer Street Department.

A more complicated form of delivery ticket, often with two or more tickets to be detached, is frequently used, but is unnecessary, as the one here recommended, if properly used, gives a complete record, and, as will be noted later, may be made to supply a complete check upon the operations.

FORM 3.— RECEIVERS' ORIGINAL RECORD.

These blanks will be supplied to receivers in detachable-sheet book form. They are to be used for recording, in the field, the receipt of each load or separate consignment of supplies received on the street without regard, at the time, to classification. Their use is apparent without explanation. After the condensed statement, Form 4, is made up all these original records for each day will be sent to the general office.

The receiver on the street is generally a busy man, particularly if the functions of receiver and inspector are combined in one man, as they often may be, and his work while actually on the street should be reduced to the simplest form consistent with fullness of record and accuracy.

FORM 4.— RECEIVERS' DAILY REPORT TO ASSISTANT ENGINEER.

This provides for the daily classification and summing up of the supplies received on the street, and keeps the assistant engineer informed of the sufficiency of supplies on hand for the proper progress of the work and the total quantities delivered.

This form should be printed on thin paper and bound in pads, so that, by using carbon paper, duplicate copies of each day's report may be retained by the receiver.

FORM 5.— INSPECTORS' REPORT TO ASSISTANT ENGINEER.

The application and use of this blank is obvious without explanation. By it the assistant engineer is daily informed of the progress of the actual work of construction and the

Form. 4.

Receiver's daily report to Assistant Engineer

Date May 7th 1908

The following is report of supplies received by me up to the end of this day, for

Pour & Reg Grave, St.

	Previously received	Received this day	Total received
Crushed Stone Tons			
Sand Loads			
Gravel "			
Granite Blocks large Number			
" " small "	300	450	750
Edgestone Lin. Feet	60	42	102
Flagging " "			
Bricks Number			

Signature B. Peters

Receiver

consumption of supplies. Items most frequently used may be printed in on the form, leaving a sufficient number of blank lines under both work done and materials used where other items may be written in. If more than one inspector is employed a condensation of their several reports by the assistant engineer will be necessary. When verified by the assistant engineer a copy of the report may be forwarded to the general office as a progress report. When the work is completed the report on this form will show the total quantity of work done and of supplies used. Comparison of the concurrent reports, Forms 4 and 5, at any time will show the balance of supplies that should be on hand, and any apparent discrepancy may be at once looked into.

The assistant engineer's final estimate when made up and returned will furnish confirmation of this report as well as the additional data required.

FORM 6.—CUSTODIAN'S FINAL REPORT.

When any requisition has been filled the custodian (or person to whom it was addressed) will make up this final report and forward it, with all the original delivery tickets relating to it, to the general office.

SUMMARY.

The system and blanks described above supply all the means necessary to trace every item of supplies, from the time requisition is made for it to its incorporation in the work, or its return to a storage yard, and for the returning of all the data relating to it to the general office where the requisition started. This data should be collated, the records verified by each other, and the proper charges made against the improvement, at the general office.

VERIFICATION AND CHECKING.

The original requisitions with their authorized modifications will supply a general check upon the quantities reported. The quantities sent to the work will be shown by the custodian's report, which in turn should be verified from the original

Form 5.

Inspector's Daily Report to Assistant Engineer
— of work done and supplies used

For _____

_____ 190____

Items		Previous to this date	This day	Total to end of day
Work Done				
Preparing Site				
Edgestone set { New	lin ft.			
Old	"			
Flagging set { New	"			
Old	"			
Granite Block laid, Gutters { New	sq. yds			
Old	"			
Granite Block laid, Roadway { New	"			
Old	"			
Brick Sidewalk laid	"			
Supplies Used				
Edgestone	lin. ft.			
Flagging	"			
Granite Blocks	Number			
Sand	Loads			
Gravel	"			
Cement	Bbls.			

Items most frequently used may be printed in this list, leaving sufficient blank lines under each work done and materials used, where other items may be written in

Signature _____
Inspector

delivery tickets. A further check will be afforded by the monthly reports of supplies on hand, received, sent out and remaining on hand at the yard from which these supplies were sent out, which report is now required. The receipt of the supplies on the street will be shown by the receiver's daily record, and may be checked by the receipts on the original delivery tickets. The disposal of the supplies after reaching the street (being thereafter presumably in the custody of the assistant engineer and his inspectors) will be shown by the inspector's or assistant engineer's report, and, in the end, the whole checked by the final estimate of the work done. There would seem to be no opportunity for the misappropriation of supplies without the collusion of at least two employees, and losses in transit between storage and street could not occur without detection and the fixing of the responsibility for such loss.

The collation of the information and the verification of quantities as well as the investigation of any discrepancies would be centered in the general office, where all the original data would be on file, and where such investigation would be disinterested and impersonal.

LABOR RECORDS.

Original records of labor performed (exclusive of salaried employees) divide themselves naturally into two classes, teaming and common labor.

In the case of teams it is difficult, if not impossible, by the rude systems of keeping time too frequently employed, to follow and check up the work actually done. Often these teams carry loads over long distances where their movements cannot be watched and delays between loads may not be noted.

The device here recommended, while not new, has never, so far as I know, been used in municipal work.

FORM 7.— RECORD OF TIME AND WORK OF TEAMS.

Teams are usually employed by some designated person and report to him, or to some other designated person, for work in the morning.

Form 6

Custodian's Final Report

of supplies issued to fill

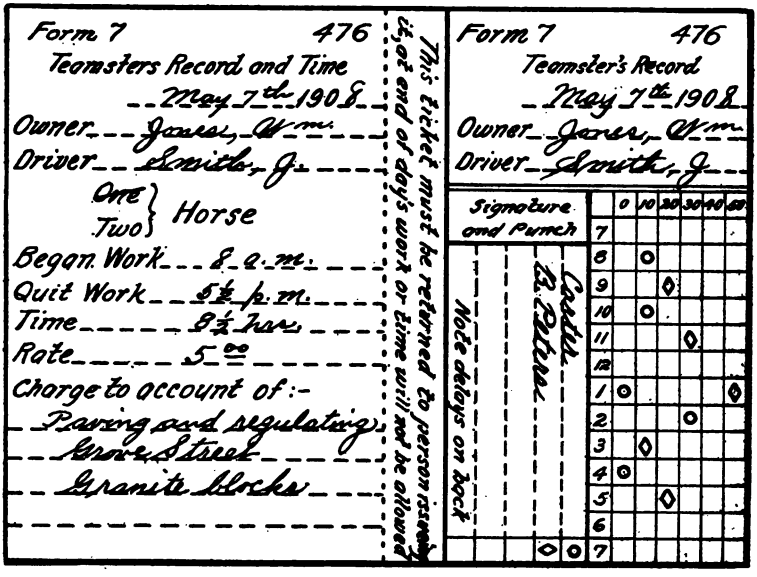
Requisition No. 24 Issued by John Sweeney

Supplies for Pav. & Reg. Brooklyn

Supplies	Quantity	Price	Value	
Granite blocks #2	4230	7¢	296	10
Edgestone	420	70¢	294	00
Credit, Supplies returned				
Granite blocks #2 No.	310	7¢	21	70
Edgestone Ft	5	70¢	3	50

May 20th 1901. Wm Page
Foreman Yard 7

In assigning each driver to work, Form 7, with its stub, will be properly filled out and the ticket torn out and given to the driver, with instructions how it must be used. On reporting to any point, as a stone crusher, for a load, the weigher will, when the load is made up and ready to leave, punch out the approximate time. On arrival at destination with the load the receiver will punch out the time of his


Form 7 476
Teamsters Record and Time
May 7th 1908
Owner Jones, Wm.
Driver Smith, J.
One
Two
Horse
Began Work 8 a. m.
Quit Work 5½ p. m.
Time 8½ hrs.
Rate 5 00
Charge to account of:-
Paving and regulating
Grove Street
Granite Blocks
This ticket must be returned to person issuing it, at end of day's work or time will not be allowed
Form 7 476
Teamster's Record
May 7th 1908
Owner Jones, Wm.
Driver Smith, J.
Signature and Punch
Note delays on back
Credit R. Pline
0 10 20 30 40 50
7 8 9 10 11 12 1 2 3 4 5 6 7

Ticket and Stub for keeping Record of Team Work

leaving for another load. This will be continued throughout the day, and the card, when returned at night, will carry a record of the operations of the team for the day. Referring to the illustrative entries on the attached card they show that the driver started with his first load about 8.10 a. m.; that he discharged this load and started to return about 9.20 a. m., and the trips for the whole day are thus shown on the card. The distinctive punch-marks will usually be recognized by the city employees interested, but to provide for identification in unusual cases provision is made

for the signature and punch-mark opposite of the persons engaged — the custodian of the supplies and the receiver.

The driver must return the ticket at the end of the day's work to the person who issued it, when the latter will complete the filling up of the corresponding stub, which will then supply all the data for making up the pay roll and distributing the account.

The use of this Form 7 is comparatively simple and easily enforced, and it should afford a pretty close check upon the operations of every team employed in hauling over considerable distances. Where, however, the work of the team is confined to a small circuit, so that it can be constantly observed by the foreman in charge, the time could be better kept and reported in time books of the usual form.

In case the pay rolls or general time sheets are not made up by the person issuing and taking up the tickets (Form 7), the stubs should be perforated along their rear edge and should be torn out and sent with the tickets corresponding to the person whose duty it is to make up the pay rolls.

In printing these forms there should be several blank lines at the bottom of the stub, so that if the team is employed on more than one account during the day the proper entries and subdivision of the time may be recorded, so as to facilitate the proper classification of the cost to the various accounts.

This form is to be printed with serial numbers and should be bound into books of convenient size.

If these tickets and stubs are preserved the pay roll accounts can be checked at any time.

It will be noted that to "pad" a pay roll where these tickets are used involves the collusion of at least three persons.

TIME RECORDS, COMMON LABOR.

The original time books for labor should serve two important purposes — a record of the time worked by each individual, so that he may be correctly paid, and a record of the particular kind of work upon which he was engaged, so that the cost can be distributed to the proper accounts to which it

belongs. The latter should be considered equally as important to the city as the former. Unless a proper system of cost keeping is employed it will be impossible to determine in any case the cost of each of the several items that make up an improvement. The cost, for instance, of granite block pavement laid by the city can only be ascertained by collecting under that head every item of cost of material and labor properly chargeable to that work. The charges for supplies are usually easily ascertainable, but as several kinds of work are usually in progress at the same time by the laborers of the same gang, the labor charge for granite block pavement can only be determined by separating the account of labor chargeable to that work from other sub-accounts.

A great variety of forms of original time records have been devised and used for thus keeping track of the cost of each item of work done. It does not seem necessary to here designate any particular form, as most engineers are familiar with the subject, and the form best suited to any one locality or set of conditions can be best selected by those in immediate charge of the work. Having decided into what sub-heads the account for any improvement, or class of improvements, shall be divided the form of the original time record may be chosen accordingly.

On works of any magnitude, where many laborers are employed, it is better to have a special timekeeper and not to intrust the timekeeping to the foreman. The latter are not often competent to do this work; they are, if attentive to their work, fully employed all the time, and cannot keep time without detriment to more important duties, and the class of men commonly employed as foremen are often not, or at least not well enough known to be, trustworthy.

They may reasonably be expected to make out and forward a daily report of the aggregate number of days' work done by each of their gangs, to be used as a rough check upon the timekeeper's work. Such a check will prevent gross errors, and will make padding of pay rolls, to any considerable extent, impossible without collusion between the timekeeper and the foreman.

A single timekeeper will usually be able to keep the time

on several improvements by visiting each at least twice a day, so that the expense of separate timekeepers will be a small item in the cost of the work.

It should always be possible to determine from the original time sheets what every laborer on the city's pay roll was doing on any particular day. If such a specific statement is required for each man each day it will be much easier to detect any attempted fraud upon the city by padded pay rolls or the carrying on the rolls of men who do little or no work.

When introducing any system differing from the one previously used, full instructions must, of course, be given to the employees interested, and clear and definite instructions for the use of each blank should be printed upon it — usually upon its back.

It may be found desirable and necessary to use additional forms, or to continue in use a number of those already employed in the Boston work, which seem to be very good. My object has been to call attention to those only which seem necessary to provide a full record of the handling of supplies and the employment of labor, and I have endeavored to do this as briefly as practicable.

It is sometimes asserted that it does not pay to incur the trouble and expense of enforcing a complete system of recording and accounting for supplies and labor such as has been outlined above; that if the work is well managed and carefully watched the aggregate cost, which is the really important matter, will not be decreased, but rather actually increased by elaborate systems of records and itemized cost-keeping. It is not necessary to argue the point. The best answer to such statements is the fact that a great majority of the better class of contractors, and nearly all the large industrial establishments, have found it advantageous and profitable to adopt such systems. It will be readily admitted that they are more desirable and important in municipal work, where careless methods are more likely to prevail, where misappropriation and fraud seem to be regarded as less criminal, and where the incentive of personal interest in the success and economy of the work done is more frequently wanting.

ITEMIZED COST-KEEPING IN STREET WORK.

Earlier in this report I have spoken of the importance of keeping careful records and accounts of the cost of street construction and maintenance and the neglect of Boston to do this. Boston is not, however, alone to be criticised in this respect. In very few cities is it possible to determine from the records what it has cost to maintain any one street for a given period of time. In a few, notably Washington and Buffalo, accurate records have been kept of the cost of maintaining each street paved with sheet-asphalt, and similar records are available of the cost of repairing that kind of pavement in Boston for a number of years past.

But no such information is obtainable with regard to other pavements. It is impossible, for instance, to find out what it costs to maintain macadam pavements in Boston, either as a whole or as to individual streets.

Until we shall have records of this kind extending over a considerable period of years, it will not be possible to determine with certainty the relative cost of maintaining pavements of different kinds so as to compute accurately their comparative economy in use, either generally or in any one city.

From what will be said further on in this report it will be manifest that the matter of judicious selection of the kind of pavement to be used on the city streets is one of great importance financially, involving, as it easily might, the saving or loss of many thousands of dollars in the course of a short period of years. But the question cannot be dealt with intelligently without accurate cost data.

The cost of collecting, recording and collating the required data would be insignificant compared with their value if intelligently used.

I would, therefore, strongly recommend that an adequate system of itemized cost-keeping be at once organized in the street paving department of the city. The records should be in such detail that it will be possible at any time to ascertain the total amount of money expended upon any given street, and this total amount should be classified under

proper sub-accounts, so that the cost of each of the several items may be determined, such as sidewalks, edgestones, gutters, and the different parts of the roadway pavement proper.

The most important and at the same time the most troublesome part of such a system of cost-keeping is the original notes and records. Upon the completeness and accuracy of these will, of course, depend the value of the deductions that may be made from them.

A card index system for entering and filing these original records has been found convenient and satisfactory. Such a system is not difficult to devise or to keep up, and your Engineering Department is competent to deal with the matter effectively. But I attach to this report (Diagram 1) a general form of card, suggested from my own experience and found satisfactory. Its details may be varied to suit special conditions in Boston. It will be readily understood and it is not necessary to here go into details of its use.

MUNICIPAL ANNUAL REPORTS.

It will be appropriate to introduce here some remarks, submitted at your request, upon the subject of annual city reports and what they should contain.

The printed annual reports of the public works department of cities have two principal uses:

1. To inform the public of the general and to some extent the detail operations of the city in the management of the public business.

2. To supply a printed record of the leading historical and statistical facts relating to the public works of the city in a convenient form for ready reference thereto by the city officials, and to form a permanent record of these facts.

In attempting to formulate an annual city report the city official or officials upon whom the duty devolves is at once met by two important questions which are difficult to decide:

1. To what extent and in what degree of detail is it important or desirable to print in the annual reports a statement of the business of the city during the year?

(Diagram 1.)

RECORD OF STREET MAINTENANCE

Street, from _____ to _____

Length _____ Ft. Width bet. Curbs _____ Ft. Roadway Paved with _____, _____ Ft. Wide

Gutters _____ Ft. Wide Sidewalks _____ Ft Wide

Repairs made between _____ 190__ and _____ 190__

Character of Repairs made _____

MATERIALS USED AND COST OF WORK

	Roadway Foundation			Roadway Surface			Gutters			Sidewalks			Edgestone		
	Quantity	Price	Cost	Quantity	Price	Cost	Quantity	Price	Cost	Quantity	Price	Cost	Quantity	Price	Cost
Crushed Stone ____ Tons															
" " Screenings ____ "															
Gravel and Sand ____ Cu. Yds.															
Cement Hydraulic ____ Bbls.															
Granite Blocks (New) ____ Number															
" " (Old) ____ "															
Wood Blocks ____ "															
Pitch ____ Bbls.															
Asphalt Mixture, Binder ____ Cu. Ft.															
" " Surface ____ "															
Bricks ____ Number															
Edgestone (New) ____ Lin. Ft.															
" (Old Reset) ____ "															
Rolling ____ Hours															
Labor ____ Days															
Foremen ____ "															
Hauling ____ "															
Sundries ____															
Totals ____															

2. What is the best and most convenient form in which to arrange and print the data that it is decided the report shall contain?

The practice of both American and foreign cities varies widely in reference to these matters. The annual report of the Department of Public Works of the City of Buffalo for the fiscal year ending June 30, 1906, is a bulky volume of 1,094 pages, embracing a large number of tabular statements, and attempting to give in considerable detail the facts and statistics relating to the business of the department for the year. There is a large quantity of matter in it that is of no interest to the citizen of ordinary intelligence and of average interest in municipal affairs. On the other hand, one who is looking for full and accurate information upon any one subject or improvement will find so many essential elements and details missing that the report is of little value to him. The reports of a number of foreign cities, so far as they relate to public work, are much better than those of most American cities, and yet when the Commission on Street Cleaning and Waste Disposal of the City of New York wanted definite information on a number of points they had to obtain it through correspondence with the city officials, or through a representative sent to Europe to collect the data wanted.

The reports of a number of American cities, while brief, are very good and reasonably complete, but they do not, usually, give all the data that any one wanting to get full and accurate information needs. The greater number of the reports attempt to give only a concise statement of the more important facts.

So far as the general public is concerned it may be safely said that not more than one-tenth of 1 per cent of the citizens in any city ever see, or care to see, the annual city reports. Of those who see or care to see them a very large majority are quite satisfied with brief general statements. Only a small fraction of the latter class will take sufficient interest in the matter to read and digest, with any degree of care, the statements and statistics printed. Of the latter class a considerable number will want the information in greater detail than it would be possible to give it in any annual municipal report without making it unduly bulky and quite expensive to print.

But there will be a comparatively large number of people especially interested in some particular improvement, or whose property interests are affected thereby, who may want to look up all the facts and details relating to that improvement, and who, if they undertake to make a thorough investigation, will find any practicable printed reports inadequate, and they must hunt up the original data in the city offices. It is, therefore, questionable whether elaborate and expensive annual reports are worth while for the benefit of the public.

The annual reports, however, are often of great value to city officials as a printed record of the business of the several departments of the city, which may be readily referred to, and their value in this way will usually be measured by their completeness and the amount of detail they contain. The preparation of annual reports — the collection, condensation and tabulation of data for them into convenient forms for ready reference and use — might not be attempted or accomplished were it not obligatory upon the official to prepare such reports; and they should, therefore, be required. Good annual reports are doubtless worth all they cost for the use of the city officials alone.

The annual reports of one city are often wanted by the officials of other cities for the purpose of making comparisons of the character, extent and cost of public works and service in neighboring cities. But their actual value for this purpose, unless uniform methods of accounting and cost-keeping are in use, is not great, and conclusions based upon them are likely to be erroneous or misleading. A statement of the cost, for instance, of constructing a given kind of pavement in one city is of little value unless accompanied by such complete information of all the local conditions and requirements as it would be impracticable to put into printed annual reports.

To make a report really valuable it must contain more than a mere statement of original facts and records; these must be digested, condensed and generalized. The system of recording and classifying the original facts must be complete, and hence a good system of accounting must precede the formulation of good reports. The accounting departments of most

cities are very defective, and when an official comes to prepare a report he very often finds that the necessary data are not available. I have had occasion to look over the Boston Street Department reports for a number of years and some of the earlier ones, as, for instance, that of 1897, seem to me very good. It would, however, have been possible to put in a great deal more data without much increasing the bulk of the report. In the matter of asphalt pavements, for instance, a single folding table might be inserted, giving in separate columns the following details of the year's work:

Name of the street.
Limits of the improvement.
Length of the improvement.
Width between curbing.
Number of car tracks in street.
Class of pavement used.
Area paved.
Date of contract.
Date of completion of work.
Name of contractor.
Foundation — character, thickness.
Pavement — binder, surface.
Period of guaranty.
Concrete — quantity, price.
Surface and binder — quantity, price.
(And similar double columns for other important items.)
All other contract items, cost.
Work done directly by city, cost.
Total cost of the improvement.

Similar tabular statements might be prepared and printed, giving the more important data for other classes of pavement and for other kinds of public work.

To make such statements most valuable they must give as many details as possible, and they must give not only quantities of work done but unit prices and total cost, or they must at least give all the elements necessary to derive both the total cost and the cost per unit of work. A statement, for instance, which gives the contract prices and the total cost of a street pavement is of little value unless it gives also the number of square yards paved, and unit prices are of little value unless it is made plain exactly what work each of these prices covers.

For the comparatively small number of people who may, for any reason, wish to make a careful examination into any one public work, as, for instance, the improvement and paving of a given street, as well as for the convenience of city officials who may have occasion to do the same, the printed annual report hardly ever will be complete enough to be satisfactory. For their benefit a more complete record is necessary and should be provided.

An examination of this character is usually very tedious and discouraging, requiring a lot of time and work. Most improvements, from their initiation to their completion, cover a considerable period of time, and the records relating to them are not only scattered over this whole period, but are to be found, if at all, in different offices or departments.

It would be quite practicable to keep all the information relating to any one project or improvement together in one office and in the care of one city officer, to be designated for the purpose. In the case, for instance, of a street or sewer improvement a file might be provided marked "File Number — of 190–," into which it would be the duty of the person designated to collect copies of every city record relating to that work. It would begin with the petition, resolution or ordinance initiating the improvement, and would be followed by abstracts of the official proceedings, the engineer's preliminary estimates, the advertisement for bids, award of contract, the contract, specifications, drawings, etc., official action and reports during the progress of the work, ending with the final estimate and payment for the work. In short, it would be a connected history, from beginning to end, of the work. The briefer data about the work given in the printed annual reports should contain a reference to this file so that any one would know where to go for complete information.

The preparation and taking care of such a set of files in a large city where a great number of public works are carried out every year would require a good deal of time and would cost quite a sum of money, but the cost would be more than repaid by the saving in the time and work of the city officials

and employees, who must frequently hunt out from various offices and records the information that the proposed file would supply at once.

The system proposed is, practically, the adoption of the method of filing by *subjects* now almost universally in use by business and professional men and private corporations. If, as is generally admitted, the value of such a system of filing increases with the magnitude of the business transacted, it would appear to be almost a necessity in the large and complicated business of a city.

While not strictly apropos to this subject of city reports, I would like to suggest, in connection with the plan outlined above, the establishment of a bureau for the collating, recording and keeping in a form for ready access and use of the large mass of valuable information and statistics that should be accumulated from the experience of every city.

In the recent report of the commission appointed by the Mayor to study and report on methods of street cleaning and waste disposal in New York, it is said:

> We recommend that the bookkeeping of the department be remodeled in accordance with the latest and most approved system of municipal accounting, and that, if necessary, special statisticians be employed to collate full and exact data relating to quantities, costs and other useful details, so that they may be readily available at all future times for guidance.

In its investigations the commission found a great lack, in the current records of the Street Cleaning Department, of necessary data as to quantities of work done, cost of doing certain kinds of work, etc., which should have accumulated from experience or from experimental work during the long life of the department, and should now be available for the guidance of the department. Even where records were found they were often not in shape to be comparable with each other. During one administration the records of quantities of street sweepings, for instance, would be in cartloads without reference to the volume of weights of the loads, during another the quantity would be given in cubic yards with no reference to the weight, during another it would be

recorded in tons, and during still another the quantity, however expressed, would be combined with other city waste.

Furthermore, examination of former heads of departments disclosed that elaborate experiments had been made in the past to determine some valuable fact, the records of which are now so buried in the archives of the department as to be practically lost, and a succeeding head of the department, not knowing of the previous work, may have duplicated the experiments at considerable cost, his conclusions being now lost in the same way. In some cases the commission, unable at the time to find any records, made original investigations, only to find out later that all the data wanted existed unknown and unavailable to the present administration. Had there existed a special bureau for the collection, preservation and classification of important records the results would be available to present city officials for their information and guidance, leading to greater economy and more effective work. Similar conditions exist in most large cities.

I am aware that I have made only general statements, while you wanted definite suggestions as to the form and character of future reports in Boston. It is practically impossible for any one to say just what the annual reports of any city might or should be without a very intimate knowledge of the system of accounting in use, the methods of conducting public work and all the local conditions that must be considered; otherwise the most elaborate formulation of details would be likely to be found impracticable and worthless. I have, therefore, not attempted more than a general outline.

CHAPTER IV.

A SUGGESTED REORGANIZATION OF THE PAVING DIVISION OF THE STREET DEPARTMENT OF BOSTON, MASS.

At the meeting of your commission on the 8th of June, 1908, I was requested to present to the commission a project for the organization of the street and pavement construction and maintenance division of the Street Department, based upon the assumption that the recommendation in an earlier report that the policy of doing all work by contract, so far as practicable, shall be adopted.

My knowledge of the details of the existing organization is not sufficiently intimate to warrant me in going into much detail as to the number and character of the employees necessary in the division forces, but these must be to some extent a matter of judgment and experience, and dependent upon the amount and character of work likely to be required in each of the subdivisions or districts.

PRESENT ORGANIZATION AND METHODS.

Street Commissioners.

The Board of Street Commissioners, under the law, take the initiative in all matters relating to the laying out of new, and the relocation, alteration or discontinuance of old streets in the city. This board prepares the official street and alley plats or maps of the city, determines the location, width and grades of all streets and alleys, and acquires all additional land that may be needed for street purposes. But the actual construction and improvement work is carried out by the Street Department upon the order of the Street Commissioners.

The jurisdiction of the Street Department over all such

work begins, therefore, when construction or reconstruction work is ordered by the Board of Street Commissioners.

I understand that the work of the Board of Street Commissioners has been highly efficient and satisfactory. No examination has been made of its organization, working or results, and, except as it may be referred incidentally, it will not be considered further in this report.

Paving Division, Department of Superintendent of Streets.

The present organization of that branch of the Street Department having control of the construction, reconstruction and maintenance of streets and pavements, called the Paving Division, is subdivided into three distinct sub-bureaus as follows:

1.— Office of Chief Engineer, Paving Division.

The chief engineer of the Paving Division is appointed by and reports directly to the Deputy Superintendent of Streets. His duties consist of supervising the construction of new or the reconstruction of old streets, the measuring up of work done, and the preparation of final estimates for contract work. He is also supposed to keep the records of supplies used.

He is assisted by three assistant engineers, two clerks, one rodman, nine inspectors, one foreman and a coachman. He is supposed to give detailed instructions and to see that all work is properly done and all supplies accounted for.

2.— Permit Office, Paving Division.

This bureau deals with all permits issued by the Street Department and reports to the Deputy Superintendent of Streets. All applications for permits to open the streets are referred to and handled by this bureau, which has charge also of the restoration of opened pavements by the parties to whom the permits are issued. All records relating to such permits are kept here.

The bureau is operated by three clerks, a staff of twelve inspectors, one electrical engineer, one aid, two messengers and a chauffeur.

3.— The Field Bureau.

This bureau is in charge of the actual work of constructing, reconstructing and repairing streets. For the purpose of this work the city is divided, geographically, into twelve districts, each having a city yard for storage, etc., and serving as the headquarters for the management of the work in the district. The work in each district is under the immediate control of a yard or district foreman, appointed by the Superintendent of Streets. Under the yard foreman are various foremen and sub-foremen, who have direct charge of the handling of supplies and the actual work on the streets.

The district foremen are under the immediate direction of and report to the Deputy Superintendent of Paving Division. Supplies for street work are usually stored at and delivered from the district yards to the streets.

The Relation of the City Engineer to the Paving Division.

Under chapter 17 of the City Charter and Acts relating thereto the City Engineer is charged with the making of all surveys required by the other city departments, and he is the official custodian of all surveys and plans relating to the laying out, relocating, altering, widening, extending, discontinuing and grading of streets.

It is his duty to supply the lines and grades for all new street work, but he has nothing to do with the actual work of street and pavement construction and maintenance.

In other words, the Paving Division and its chief engineer are dependent upon the City Engineer for all the official data necessary in the planning of new work, including the setting out of lines and grades.

THE PRESENT WORK OF THE PAVING DIVISION.

The work now done by the Paving Division of the Street Department may be classified as follows:

1. The construction of new streets, including grading, guttering, curbing (edgestone), and constructing sidewalks, or so much of these as may be necessary.

2. The construction of new pavements on old streets,

including the necessary incidental work. A part of the above work is done under contracts, and a part directly by the city forces, organized for the purpose.

3. The reconstruction, repaving and the general repairing of old streets, with necessary incidental work.

A part of this work is also done by contract.

4. The maintenance of special pavements that are under guaranty for a period of years, or that are maintained by contract after the expiration of the guaranty.

5. The restoration of openings in streets and pavements made under permits where such restoration is not made by the persons to whom permits are granted.

6. Minor current repairs to streets and pavements and their appurtenances.

7. The cleaning of streets not under the jurisdiction of the Street Cleaning and Watering Division.

8. The furnishing and handling of nearly all the supplies for construction, reconstruction and repair work, whether done by contract or by the city forces direct.

FUNDAMENTAL CHANGES RECOMMENDED.

Before taking up the suggested changes in the organization of the Paving Division some important changes in the scope and work of the division will be considered and recommended.

Contract and Direct Work.

Any contemplated reorganization of the Paving Division will be affected by the question of how much of the street work shall be done in the future by contract and how much of it by the city forces direct. I have already strongly recommended that, as far as practicable, all street work should be done by contract. Taking the work of the division as enumerated and classified above I now recommend that all the work under subdivisions 1, 2, 3 and 4 be done wholly by contract, the contractor to furnish all the supplies required; that the work under subdivisions 6 and 7 be done by the city forces direct, and that a larger part of the work under subdivision 5—the restoration of street openings—shall in the future be done by the city forces direct, as explained later.

The work classified under 1 and 2 has, heretofore, mostly been carried out by a combination of the contract and the direct methods — the city has furnished most of the supplies, and the construction work has been done partly by contract and partly by the city forces.

In the work under subdivision 3 (commonly called paving and regulating) the city has not only furnished the greater part of the supplies required, but has, with its own forces, done a large part of the reconstruction and repair work. The objections to a division of the work between city and contractor, and the advantages of letting contracts for the whole construction have already been pointed out earlier in this report.

The work classified under subdivisions 6 and 7 is of such a character that it is usually difficult to define, limit and specify it in such a way as to make contracts practicable. Its amount and exact character cannot well be determined in advance so that contractors may be able to submit intelligent bids therefor. The difficulties of accurate measurements and classification so that unit prices may be applied in paying for it are usually so great, and the possibilities of misunderstanding between contractor and city so many, that satisfactory contracting is usually out of the question.

Restoring Street Openings.

Under the present system in Boston the city makes but a small part of the repairs to streets and pavements covered by subdivision 5— the repairing of permit openings. The persons to whom the permits are given are required to restore the pavement, and the Paving Division makes such restoration only where these parties fail to do so. Experience in a number of cities has demonstrated that it is advisable for the municipality to make these permit repairs with its own force, except in those cases where the openings are made by responsible corporations equipped with the necessary men and plant to do the work properly. The work of restoring pavements that have been opened requires special skill and care. Where it is attempted by unskilled persons or by ordinary pavers, or persons employed by them, the work

is not likely to be properly done. The large quasi-public corporations have usually a sufficient equipment of forces competent to do the work, and with proper supervision they can be depended upon to do it properly. With the exception of these it will be found better and more satisfactory to have the city forces restore all openings into streets and pavements. In the cities where this is done the persons to whom opening permits are granted are required to deposit, before the permits are issued, a sum equal to the estimated cost of making the restoration, which sums, as collected, are credited to the street maintenance fund of the department; or, if the money is not actually paid in, they are required to give satisfactory security for its payment when due. I respectfully recommend that this general plan be adopted in Boston.

Engineering in the Paving Division.

At the present time the City Engineer's office has practically nothing to do with street and pavement construction except to supply records of which that office is the official custodian and to give lines and grades to the Street Department. The wisdom of this arrangement is more than doubtful. The department of engineering in any large municipality should be a distinct and united organization. Its special province is to design and supervise the construction and maintenance of the public works of the city. These public works should be planned and carried out with unity of design and purpose, and this result can best be secured where the whole engineering department of the city is under one responsible head and management.

Furthermore, the best results are likely to be attained where the Engineering Department, while free to co-operate, is largely independent of the administrative departments. The motives and interests of the heads of these several co-ordinate departments are likely to differ widely, and each is likely to advocate the measures that will most benefit his particular department. Separate engineers, subordinate to these department heads, are likely, acting under instructions from their superiors, to adopt diverse policies and plans,

not in harmony with a general scheme that would be clearly best for the city as a whole.

Upon the engineering department a city must largely rely for the efficiency and success of its public works. To properly discharge its duties this department must have a certain amount of independence, authority and latitude for the exercise of judgment. Where in the various administrative departments each maintains an independent engineering organization of its own, the engineer being appointed by or for the head of the department and subject to his control, it cannot be expected that the engineering work in the several departments will be properly co-ordinated, even if the requisite authority and independence of action be conferred on the departmental engineer. This will be found particularly true where departmental engineers are appointed for political or personal reasons rather than because of merit and efficiency.

One of the most important duties of the engineering department is to see that work in progress is carried out in accordance with plans, specifications and instructions — in short, that the work is done in the proper manner. In the case of work done by contract this is universally recognized. It should be just as true of work done by the city direct, where watchful supervision by the engineer is often as necessary to secure good results as on contract work. Consequently, the engineer must be free to exercise the same independent and responsible control over departmental work coming within his sphere as over contract work. This may not be possible if he himself is a creature of the department, subject directly to the orders of its head.

Sound principles and good practice dictate, I believe, that all the engineering work of a city should be concentrated in a district engineering department, independent of co-ordinate departments; and that where construction work is carried on by any administrative department its engineering features should be wholly under the control of the engineering department. In other words, improvements to be done by the city forces should not only be designated and supervised by the engineering department of the city, but while the work is in

progress the relation between the engineer and the city force should be in the main the same as that between engineer and contractor. The same rigid compliance with plans, specifications and sound construction should be insisted upon in the one case as in the other.

Whatever other action may be taken with reference to the reorganization of the Paving Division I strongly recommend that the present engineering force of the division be transferred to the department of the City Engineer, who shall be given full authority over the design and construction of streets and pavements, subject, of course, to the present authority and control vested in the Street Commission. Not only should the supervision of all contract work for street construction and maintenance be placed in the hands of the City Engineer, but all the other engineering duties now performed by the chief engineer of the Paving Division should be turned over to that department.

REORGANIZATION OF THE PAVING DIVISION OF THE STREET DEPARTMENT.

If, as recommended, street construction and reconstruction work and the maintenance of the special classes of pavements be done in the future by contract, the work of the Paving Division would be confined to the making of ordinary repairs to streets and pavements, the cleaning of outlying streets not covered by the Street Cleaning and Watering Division, and to repairing permit openings. The maintenance and operation of the stone crushers will also, it is assumed, be dropped by the Paving Division.

The work that would remain to be done by the Paving Division would be very much less, both in scope and volume, than that now attempted.

The cutting out of construction and reconstruction work, which is subject to much variation in volume from time to time, would remove the principal cause of fluctuation in the forces of the division, and it would, therefore, be possible to organize and maintain it on a fairly stable and permanent basis.

The Superintendent of Streets, acting through his deputy, would continue to be the official head of the division.

The work of restoring or of supervising the restoration of street openings should be placed wholly in charge of this division, and be under the direction of the deputy superintendent, where it appropriately belongs.

The duties and work of the permit office could then be largely reduced, as it would be confined to the issuance of permits and the adjustment of accounts for permit repairs. The actual work of restoring street openings can be more conveniently looked after by the district foreman than by the permit office. A considerable part of this restoration work would be done by the city forces direct, and where done by other parties could be supervised by the district foreman in whose district the work is located. This matter will be referred to more in detail further on in this report.

The permit office now employs three clerks, twelve inspectors and five miscellaneous employees. Under the suggested change two clerks, two assistants (to act as messengers when necessary) and one inspector (to look after the permits for purposes other than street openings) should be sufficient to attend to the work.

Proposed Reorganization.

The general plan of the proposed reorganization of the Paving Division is very simple. The present engineering bureau being detached, and the permit bureau reporting to the Superintendent of Streets, there would remain the Deputy Superintendent of the Paving Division and his district foremen, who would report directly to him.

It will not be attempted in this report to deal with the details of the equipment and operation of the reorganized division, except in so far as it may seem necessary to outline clearly the general scheme of management.

The unit of the organization would be the district, under the direct charge of a district foreman, each of whom would report directly to the Deputy Superintendent of the Paving Division.

The Deputy Superintendent.

The qualifications essential in the Deputy Superintendent are good executive capacity and a thorough practical knowledge of the maintenance of streets and roads. It would be necessary for him to spend a large part of his time on the streets, to direct and advise the district foremen, and he should have a competent chief clerk and such additional clerical help as might be found necessary to properly conduct the work of his office.

Districts and District Foremen.

As twelve districts have already been established, with a headquarters and storage yard for each, it would probably be advisable to retain them as they are. Otherwise, a smaller number, say eight or ten districts, would be equally satisfactory and more economical. Not only would the services of two or more district foremen, with their incidental clerks, etc., be thus dispensed with, but the somewhat larger forces attached to each could be handled on the streets with fewer foremen, and the larger gangs could often be worked to better advantage.

Each district would be in charge of a competent district foreman, who would supervise the work in his district, and would report directly to the deputy superintendent.

Employees at the Yards.

A single competent clerk at each district office should be able readily to handle all the clerical work, such as the keeping of all records, making reports to the deputy superintendent, keeping track of supplies and making up the weekly pay rolls. A bright young assistant would note and count supplies received or issued and serve as messenger and general utility man at the yard.

Not more than eight horses would probably be quartered at any one yard, and a single stableman, working eight hours per day, say from 5 to 9 in the morning and from 3 to 7 in the afternoon, would be sufficient. He would clean the stables, water and feed the horses and clean them when

they come in from work. Drivers should be required to harness and hitch up and unhitch and unharness their horses, and to feed them at noon.

At the present time forty-one watchmen are on the pay roll of the division. A considerable number of these are employed at the stone-crushing plants, but watchmen seem to be employed at most of the yards.

If the stone-crushing plants are disposed of no watching will be necessary on their account.

The necessity of maintaining watchmen at the yards during either the day or night is not apparent, and there will be still less necessity under the proposed organization, as a smaller quantity of supplies will then be stored and fewer horses will be kept in the stables. Full insurance, even if high rates are demanded, will be cheaper than the employment of watchmen.

Street Forces.

The street force to be employed in each of these districts would necessarily differ both as to the number and the vocation or trade of the men, which would vary with the extent of the work to be done and its prevailing character. Thus, in a district where the pavements are largely granite blocks more pavers must be employed than in a district where most of the streets are macadam.

A typical outfit for a granite-paved district would be:

A main gang, consisting of:

1 foreman.
2 pavers.
2 rammers and fillers.
1 stone dresser, edgestone and sidewalk man.
8 laborers.
1 team and truck.
3 horses and carts.

Also a secondary gang for repairing openings and making miscellaneous repairs, consisting of:

1 assistant foreman.
1 paver and rammer.
3 skilled laborers.
1 horse and cart.

A typical outfit for an important district where the streets are largely macadam would be:

A main force as follows:

1 foreman.
1 paver and rammer.
1 stone dresser and edgestone man.
10 laborers.
2 teams and trucks.
1 horse and cart.

and a street-cleaning gang:

1 assistant foreman.
8 laborers.
2 teams and trucks.
1 horse and cart.

All the men should work at whatever they are directed to do regardless of their particular trade. The pavers, rammers and stone dressers, for instance, while skilful in those particular kinds of work, would do other things when not engaged in their particular line. The forces should be made up with a view to the general skill and usefulness of every man employed. There would be no place in these street forces for inefficient or decrepit men.

The actual make-up of the district forces can only be determined from an intimate knowledge, gained from experience and observation, of the character and quantity of work to be done in each district. The labor outfit outlined above should be regarded as the maximum forces likely to be needed in any district. In most of the districts much smaller gangs would doubtless be found inadequate to take care of all the work to be done.

The present forces maintained in the several districts cannot be used as a satisfactory guide. Not only are they inefficient, but they now attempt to do much work that it is proposed to have done hereafter by contract, and the records are not so kept that the one class can be separated from the other. Nor is it possible to base the required force wholly upon experience in other cities, where conditions may differ quite widely from those in Boston.

With the work of the Paving Division restricted as herein recommended, and with the district forces properly organized and managed, it is believed that the forces outlined in the final column of Table No. 28 would be sufficient to keep the streets and pavements in good repair, including the restoration of a part of the permit openings, and the cleaning of outlying streets not covered by the Street Cleaning Division.

While comparisons of this proposed force with that now employed in the Paving Division cannot be fairly made, for the reasons stated above, it may be of some interest to show in parallel columns the present and the proposed organization side by side, to give some idea of their relative magnitude and cost. This is done in Table No. 28, attached hereto.

In explanation of the column in this table showing the present force it should be said that the list is taken from the pay rolls of the division for the week ending April 30, 1908, but it should not be inferred that all the employees given in the list worked all the time, though most of them did so. Nor should it be assumed, on the other hand, that this pay roll for the week ending April 30, 1908, represents a fair average of the weekly pay rolls for the year. There is good reason to believe that it represents about the smallest pay roll for any week during the year, unless it be for a few of the winter weeks.

Table No. 28. — Street Department, Boston, Mass.

Classified List of Employees in Paving Division, According to Pay Roll for Week Ending April 30, 1908. (Includes Permit Office but not Engineer's Office.) Also Similar List of Employees in Proposed Reorganized Paving Division.

Designation.	Number of Men in	
	Present Organization.	Proposed Organization.
Deputy superintendent	—	1
Clerks, etc., in deputy superintendent's office	—	4
Clerks, permit office	3	3
Inspectors, permit office	12	1
Messengers, etc., permit office	5	3
District foremen	12	12
Clerks, district offices	9	12
Inspectors, district offices	21	12
Messengers and assistants, district offices	4	12*
Foremen	12	12
Assistant and sub-foremen	37	18
Tallymen	9	—
Weighers and wharfingers	7	—
Enginemen	15	3†
Firemen	2	—
Carpenters and helpers	25	8
Painters and sign painters	4	2
Stonecutters and masons	18	18‡
Pavers	52	24
Rammers	6	18§
Blacksmiths and helpers	16	6
Harnessmakers	2	1
Stablemen	30	12
Teamsters	86	60
Watchmen	41	6
Yardmen, janitors and tagmen	6	—
Powderman	1	—
Laborers	336	190
Total men	771	438
Horses	127	90

* General utility men.
† To run steam rollers.
‡ Includes edgestone and sidewalk men.
§ Includes joint fillers, etc.

As remarked before the list of employees in the last column, proposed for the new organization, is only tentative and when in actual operation might have to be materially modified; but it is believed to be substantially adequate for the work proposed. This statement is made not wholly as a matter of opinion. The experience of other cities has been drawn upon as far as practicable in making it up.

Thus, a detailed statement of the operation of the Street Maintenance Department of Brooklyn, N. Y., in the year 1904, is available. At that time the population of Brooklyn was about double, its mileage of paved and macadamized streets was about one-eighth greater, and its area of pavements about one-fifth greater than the population, street mileage and area of pavements in Boston.

The number and classes of men employed during the working season (exclusive of street watering and of some special and miscellaneous classes) were substantially as follows:

Foremen	27
Pavers	30
Rammers	18
Curb setters	12
Laborers	219
Total men	306
Horses	133

It should be noted, however, that the character of the streets to be kept in repair in Brooklyn and in Boston are quite different. In Brooklyn less than 10 per cent of the streets are of macadam, while in Boston over 70 per cent are macadam. The average cost of maintaining macadam streets, other things being equal, is greater than that of maintaining the more permanent pavements, and the proportionate force required would, therefore, probably be greater in Boston than in Brooklyn. This condition has not been overlooked in outlining the force that will probably be required in Boston. Thus, in Brooklyn one laborer seems to have been employed for each 2.95 miles of street, while for the proposed Boston outfit one laborer is provided for each 2.65 miles of street.

It is stated that the Brooklyn streets were kept in excellent repair with the force named.

Repairs to Plant.

All the repair work on plant should be concentrated at some one central yard, and a suitable shop provided and equipped for the purpose. This will, in the end, be found much cheaper and more satisfactory than to maintain a repair equipment and force at each yard, as seems to be done now. The time lost in carrying tools and horses to the general shop would be more than compensated for by the concentration of shop work and the fewer employees of this class that would be necessary.

The staff at this shop might consist of:

1 shop foreman.
1 clerk and timekeeper.
4 carpenters.
4 carpenters' helpers.
2 blacksmiths.
2 blacksmith's helpers.
2 horseshoers.
2 horseshoers' helpers.
2 painters.
1 harness mender.
2 laborers.
1 janitor and watchman, living on the premises.

The carpenters could be called to the street temporarily if needed for any work in their line.

Supplies.

Under the proposed plan the quantities of the various supplies required for the work of the division would be comparatively small, except in the case of crushed stone. A stock of these supplies should be kept at each yard, to be drawn upon as needed. Crushed stone might often be bought, delivered on the street, from convenient private crushers, or obtained from the city main storage yards. Accurate accounts of all supplies received, used or otherwise disposed of should be kept and reported to the deputy superintendent, suitable blank forms being provided for the purpose. All supplies used on any work should be reported by the foreman to the district office, and all supplies issued should be fully accounted for.

Inspectors.

If competent street foremen are employed and the district foremen keep in close touch with the work on the streets, as they should, no inspectors would be necessary on the work done by the city. But the restoration of street openings by other persons and corporations permitted to do such work would need to be carefully looked after, and a sufficient number of inspectors to do this should be provided in each district. They would be under the direction of the district foreman, would report to him, and should reside in the district. A single inspector in each district should be sufficient, and when not at work on openings they could be usefully employed in inspecting supplies received and upon miscellaneous work.

The nine inspectors now attached to the office of the chief engineer of the Paving Division would, presumably, be transferred with that office to the City Engineer's office.

Engineering.

Whatever engineering might be found necessary in the Paving Division would be attended to by the City Engineer, who would exercise such general supervision over the methods of street maintenance and the quality of the work done as might be found necessary.

Permits.

The permits now issued by the permit bureau may be divided into two general classes:

1. Permits for opening the streets and pavements for the purpose of constructing or repairing underground structures.

2. Permits not directly affecting the physical condition of the streets, pavements or sidewalks. A large number of these relate to the construction, repair or attachments to buildings, and a considerable number are in the nature of licenses to transact business on the streets.

The first class can be best handled by the Paving Division, but the second class could be more appropriately referred to and dealt with directly by the Superintendent of Streets or a deputy. While they relate to matters usually classified as

belonging to the Street Department, they have no connection with the physical condition of the streets and consequently do not belong appropriately in the Paving Division.

It would, therefore, be better that the permit bureau should be attached directly to the office of the Superintendent of Streets, and that notices of all permits for street openings should be promptly referred to the deputy superintendent of the Paving Division, to be by him referred to the foreman of the district in which the opening is to be made, with instructions to make the necessary repairs, or to see that they are properly made by the parties to whom the permit is issued as promptly as possible. In any event, the permit bureau should confine itself to the clerical work involved and should be relieved of everything relating to the actual work on the streets, which belongs appropriately to the district foreman.

If the permit office were thus relieved of the duty of looking after the restoration of street openings its work would be greatly reduced, and its expenses should be cut from about $10,000 (the figure for 1906) to about half that sum.

Guaranty and Contract Repairs.

The guaranty to keep a new pavement in repair for a period of years, being a part of the original contract for the construction of the pavement, should be looked after and enforced by the office having control over the original contract.

This is true also of repairs to streets and pavements done by contract; as, for instance, where contracts are made to keep an asphalt pavement in repair for a period of years at a stated price per square yard for the repairs made. It being the duty of the City Engineer to supervise the proper execution of all contract work, his assistants and inspectors should look after such guaranty and contract repairs.

Economical Results.

As previously stated, the work done by the proposed reorganized Paving Division would be so different from that now done by the division that a fair comparison of the present cost of the division with the estimated cost under the reor-

ganization can hardly be made. It may be confidently stated, however, that the net result would be the saving to the city of a very large sum of money every year.

I think I have made it clear earlier in this report that the work it is now proposed to eliminate from the Paving Division, the construction and reconstruction of streets and pavements, could be done by contract much more economically than it is now done by the Street Department forces. I have no doubt that under the reorganized Paving Division, conducted upon sound business principles and efficiently managed, the cost of the purely maintenance work could also be greatly reduced.

If, as is confidently believed, the proposed organization and equipment outlined in the last column of Table No. 28 would be found adequate to keep the streets in a condition of repair as good or better than they are now kept, some idea of the economy that might be expected can be formed from a comparison to the present with the proposed force as shown in that table.

Without attempting to make a detailed estimate, for which sufficient data is not at hand, I believe that the amount that might thus be saved annually, as compared with the present cost of the same work, would be in the neighborhood of $150,000.

CHAPTER V.

GENERAL CONSIDERATIONS RELATING TO STREETS AND STREET PAVEMENTS IN BOSTON.

INTRODUCTORY.

In the preceding pages of this report I have considered various phases of the construction and maintenance of streets and street paving in the City of Boston and matters relating thereto.

It seems appropriate now, in bringing my studies upon this particular department to a close, to submit some general observations and conclusions relating to the subject which I trust may be of interest and value to your commission and to the municipality.

Taking the area of roadway pavements of the various kinds, as given in the annual report of the Street Department for 1906, and applying to them average cost prices in the Eastern United States, it may be shown that the present roadway pavements now on the streets of Boston should have cost not less than twenty millions of dollars. They have, in fact, cost much more, because the prices paid have been exorbitant, as my previous reports have shown.

It is not possible to determine from the reports of the Street Department just what is the annual cost of maintenance and renewal of the street pavements of the city, but an examination of the annual reports for several years indicates that it does not fall much short of $1,000,000 per year.

Allowing for interest on the sum invested, it is probable that the city spends more money annually for streets and pavements than for any one other public utility.

At the same time it is doubtless true of Boston, as of most other American cities, that the subject of roadway pavements receives less scientific and economic consideration than any

other department of municipal public work. It is known in a general way that some particular kinds of pavement are best suited to streets of a certain character, where certain conditions of travel and business prevail; that some pavements are more durable than others; that some pavements are more hygienic than others; some noisier than others; some more comfortable to travel over; and upon the whole there is a variety of opinion as to which of the several kinds of pavement available should be selected for use on the different classes of streets, but that opinion is based upon general impressions rather than upon the results of such scientific investigation as we apply to other branches of engineering work.

The fact is that neither the public nor the municipal engineers have ever taken sufficient interest in the matter to impel them to collect the data necessary for an intelligent study of the subject.

While it cannot be attempted in such a report as this is intended to be to present anything like a full discussion on street pavements, it is necessary, in order to deal with the subject intelligently, to state some leading facts and principles which should have a controlling influence in the selection of pavements for any city.

When a street roadway is to be paved the first question that arises and must be decided is, what kind of pavement shall be used?

To correctly answer this question involves the consideration of the relative value in use of the different kinds of pavement available, and their adaptability to the varying conditions to which city streets are subjected. This may be called the economics of street pavements.

A street pavement may be considered from three main points of view:

Public comfort, public hygiene, economy.

In point of relative importance these are usually placed in the reverse order, economy being popularly regarded as by far the most important. I have long believed that they should stand rather in the order named.

In our modern urban life the element of personal comfort,

which we may for present purposes consider to embrace convenience and artistic merit as well, is becoming more and more a controlling factor, which we recognize and approve. If justifiable and commendable in our homes, it must be equally justifiable and commendable in the streets in front of those homes. This is mentioned here not to be further discussed, but merely to call attention to the fact that the tendency of the times is to demand something more than mere utility in the pavement of city streets.

So, also, in the matter of the sanitary qualities of the different pavements, more and more attention is being given to city hygiene, and the public health is coming to be regarded as the most important consideration in city life. In so far, therefore, as the public health is affected by the pavements on our streets they become a matter of great importance. It is doubtful, however, if there is actually as much difference in the hygienic value of the different pavements, when properly constructed, as is often claimed, and to the extent that this is true it becomes of less practical urgency, though of none the less theoretical importance. Any proposed new kind of pavement that can be shown to be distinctly unsanitary must be rejected, whatever other merits it may possess. What is of more practical importance is the question of how far imperfect or improper construction of the present standard pavements may affect the public health.

ECONOMICS OF STREET PAVEMENTS.

The economic questions involved in street paving are, to the public mind, the more immediately important ones and more appropriate for discussion in this report. Some of them only can be considered.

If we regard a pavement merely as a business enterprise the question becomes — what kind of pavement if laid on a given street, subject to known conditions, will yield the best return upon the money invested in it?

Like other industrial questions this must be considered on business principles and in the light of the facts so far as these are known. It cannot be intelligently decided offhand or by mere casual opinion.

It is hardly necessary to say that there is a wide range of opinion in the public mind as to the comparative value and economy of the several pavements, and even among municipal engineers opinion is more or less divided. It is, therefore, proper to say that what follows represents my own personal judgment and conclusions, but it may not be out of place to add that these conclusions are the result of special studies and observations in many American cities, extending over more than a score of years, and of a large experience in the actual construction and maintenance of pavements. It is also proper to say that the opinions herein expressed generally agree closely with those of other engineers and specialists who have made street paving a subject of careful study.

The cost of a street pavement should be treated as an investment to accomplish a certain purpose with the smallest expenditure of money. The purpose is to keep a street properly paved, and, considered from the business standpoint, the question may be stated thus: How may a suitable pavement be maintained upon the street at the lowest cost per square yard per year?

It is quite common to base opinions of the economy of a pavement upon its cost price and its durability. These two elements are important only as they may affect the general account. Considered independently they may not only be of little real value, but may lead to erroneous conclusions. The first cost of one pavement may be double that of another, but if it gives three times as much return in service it is obviously the cheaper of the two.

Durability, as applied to a pavement, is only a comparative term.

The relative durability of pavements has been a subject of wide discussion, often based on wrong assumptions, misinformation, or erroneous standards of comparison.

The life of a pavement is determined by two wholly different factors, or by their combined effect—the natural durability of the materials of which it is constructed and the wear and tear of travel.

All pavements are subject to more or less deterioration by age and the action of the elements, even if subjected to

no travel. But some are thus affected more than others. Thus, a well constructed granite block pavement on a concrete foundation should last, if undisturbed, for a long period, while an untreated wood-block pavement on a gravel foundation will be destroyed by natural decay in a few years. So far as destruction by natural decay is concerned, the life of a pavement is independent of the quantity of travel over it.

On the other hand, it is now well recognized that, disregarding the element of natural decay, the life of a pavement is measured by the quantity of travel to which it is subjected. In other words, if of two pavements, equal in other respects, one is subjected to double as much travel as the other its life in years will be but one-half that of the other. Consequently, in pavements that are worn out before they are affected by natural decay the only true measure of their life is, not the number of years they will last, but the total quantity of travel they will carry before they are worn out. The statement that a certain pavement on a certain street has lasted a dozen, or any other number of years, gives no idea of its durability unless the quantity of travel, say in tons per square yard per year, is also given. In other words, the endurance of a pavement is not measured by years but by the total service it is capable of giving.

To the neglect of this principle is largely due the very conflicting statements that are common about the relative durabilty of the several kinds of pavement. Until cities shall appreciate the importance of keeping a record, as by censuses of travel at regular intervals, of the quantity of travel carried by at least a few representative streets we shall have no exact knowledge of the relative durability of the several kinds of pavement, and in the meantime we must rely on such results of general observations as may be available.

The factors that must be taken into account in determining the comparative economy of the different pavements are the following:

1. The original cost of the pavement.
2. Interest on the original cost.

3. Payments to a sinking fund to redeem at some future time the debt incurred for construction.

4. Cost of maintenance, including cleaning and watering.

5. The useful life of the pavement, usually called its durability.

6. Value of the worn-out pavement for purposes of renewal.

Unfortunately the data for determining the value of some of these factors is far from complete or satisfactory. The first cost can usually be determined, and the prevailing rate of interest on money is known. For some kinds of pavement we have fairly satisfactory data as to cost of maintenance, for others we have not. The relative, but not the actual durability, or life, of most of the pavements in common use is fairly well known to engineers, though the public generally has a wrong conception of it.

We shall be compelled, therefore, to make use of the best information available in the discussion that follows, and it is obvious that the conclusions arrived at may be only approximately correct, but the errors due to lack of complete data are likely to be so small and unimportant that they will hardly change the general conclusions.

Using the best information available we may compute the cost per square yard per year of keeping a street properly paved with a given kind of pavement for any period of years.

Take, for example, a first-class granite-block pavement on the heaviest traveled business streets of the City of Boston. The original first cost, including the necessary excavation, should be about $3.86 per square yard. If the pavement be paid for by an issue of bonds, the interest paid on the bonds is justly chargeable to the pavement. Assume that the pavement will last, with ordinary repairs, thirteen years before it needs to be reconstructed. During this period the pavement will require more or less ordinary repairs, which we will not be very wrong in estimating will cost an average of 1½ cents per square yard per year, which obviously is also a legitimate charge against it that must be taken into consideration.

The reconstruction will not cost as much as the original construction, because the excavation will have been done, and the concrete foundation should be still good and avail-

able for the reconstructed pavement. The old blocks taken up should still have a value equal to the cost of taking them up, and of making such incidental repairs to the concrete as may be found necessary.

The cost of reconstruction with new blocks would be about $3 per square yard, and when completed the pavement should be practically as good as the original pavement when new.

The cost of reconstruction should be met without increasing the original debt, since it is really a part of the permanent maintenance of the pavement, and to do this we may provide a sinking fund by setting aside each year during the life of the original pavement a sum which, at the time the reconstruction must be undertaken, will amount to its estimated cost.

The operation of renewing the pavement may be repeated any number of times in this way, without increasing the debt incurred for the original construction. But this debt will remain, and if the bonds were issued for a period of thirty years a sinking fund must be established to take them up when they fall due.

We have now provided for the structural expenses of the pavement, but other expenses must be incurred to care for it properly. It must be kept clean, and inasmuch as the cost of cleaning the different kinds of pavement varies, we must, if we wish to compare the cost one with another, take this expense into consideration. The same is true of watering, but if a granite pavement be kept properly cleaned watering will not be necessary and we may disregard its cost.

Considering all these items we may make up the cost of maintaining one square yard of the pavement per year as follows:

Interest on first cost ($3.86 at 4 per cent)	$0 154
Annual payment to sinking fund to redeem bonds in thirty years, interest 3½ per cent.	075
Annual payment to sinking fund to provide sum necessary for reconstruction at end of thirteen years	152
Cost of ordinary repairs during the life of the pavement per square yard per year	015
Cost of cleaning per square yard per year, say	190
Total cost per square yard per year	$0 586

We thus find that the actual cost of this pavement to the city is about 59 cents per square yard per year.

Every item here entered is a legitimate charge against the pavement, though it is not asserted that the amount charged is strictly accurate. The method followed is in principle the same as any careful business man would apply in getting at the true cost of the products of his factory. Assuming the same general conditions we may make similar computations to determine the annual cost of other kinds of pavement.

It is only by the application of such methods that the annual cost, and therefore the comparative economic value of the different kinds of pavement, can be intelligently ascertained.

Applying this method to the three kinds of roadway pavement most largely in use in Boston — granite-block, sheet-asphalt and macadam — we may compute the annual cost of each under average conditions. These conditions obviously vary with the character of the streets, which for our present purpose may be divided into four general classes:

A. Streets with a very large volume of travel of the heaviest character, as central business streets.

B. Secondary business streets with travel of moderate volume and weight.

C. Main city or suburban thoroughfares having a large volume of comparatively light travel.

D. Suburban or residence streets where travel is mainly of a local character, and light.

A different character of construction for the same kind of pavement is appropriate for these different classes of streets, and its first cost will therefore vary with the class. For instance, granite-block pavements for Class A and Class B streets should be laid upon a concrete foundation, while for Classes C and D a broken stone foundation may be sufficient, and where a concrete foundation is used its thickness may vary with the different classes of streets. This matter will be further considered later in this report.

Considering, first, granite-block pavement we may figure its annual cost per square yard for the four classes of streets as shown in the following table:

Table No. 29.—Cost of Granite-block Pavements.

	Classes of Streets.			
	A.	B.	C.	D.
Specifications:				
Foundation	6-in. con.	5-in. con.	6-in. br. st.	6-in. br. st.
Depth of blocks	7 in. by 8 in.	6 in. by 7 in.	6 in. by 7 in.	6 in. by 7 in.
Joints filled with	grout.	grout.	grout.	grout.
First cost, original pavement	$3 86	$3 45	$3 30	$3 30
Cost of renewal	$2 45	$2 40	$2 20	$2 20
Estimated life in years	13	17	16	20
Annual cost of pavement per square yard:				
Interest on original cost, 4 per cent	$0 154	$0 138	$0 132	$0 132
Payment into sinking fund to redeem bonds, 30 years at 3½ per cent	075	067	064	064
Payment into sinking fund to meet cost of renewal, at 3½ per cent	152	106	105	078
Average cost of ordinary repairs	015	010	010	005
Cost of cleaning, per year	190	118	118	079
Total annual cost per square yard of maintaining the pavements	$0 586	$0 439	$0 429	$0 358

In the same manner the cost of sheet-asphalt pavement, per square yard per year, may be computed as in Table No. 30.

Table No. 30.—Cost of Sheet-asphalt Pavements.

	Classes of Streets.			
	A.	B.	C.	D.
Specifications:				
Foundation	7-in. con.	6-in. con.	5-in. con.	4-in. con.
Thickness of binder course	1½ in.	1½ in.	1 in.	1 in.
Thickness of surface course	2 in.	1½ in.	1½ in.	1½ in.
First cost of original pavement	$2 98	$2 64	$2 32	$2 15
Cost of renewal	$1 55	$1 45	$1 35	$1 35
Estimated life in years	9	12	14	16
Annual cost of pavement per square yard:				
Interest on original cost, 4 per cent	$0 119	$0 106	$0 093	$0 086
Payment into sinking fund to redeem bonds, 30 years at 3½ per cent	058	051	045	042
Payment into sinking fund to meet cost of renewal, at 3½ per cent	149	100	076	064
Average cost of ordinary repairs	100	040	030	016
Cost of cleaning	150	084	084	056
Total annual cost per square yard of maintaining the pavements	$0 576	$0 381	$0 328	$0 264

The annual cost of macadam pavement may be arrived at as shown in Table No. 31.

Table No. 31.—Cost of Macadam Pavement.

	Classes of Streets.			
	A.	B.	C.	D.
Specifications:				
Thickness of metal	9 in.	8 in.	7 in.	6 in.
Estimated life in years	5	6	7	10
First cost per square yard	$1 26	$1 16	$1 05	$0 94
Cost of renewal	64	60	51	51
Annual cost of pavement per square yard:				
Interest on original cost at 4 per cent	$0 050	$0 046	$0 042	$0 038
Payment into sinking fund to redeem bonds, 30 years at 3½ per cent	024	022	020	018
Payment into sinking fund to meet renewal, 3½ per cent	119	092	066	043
Average cost of ordinary repairs	400	250	150	040
Cost of cleaning	150	080	070	030
Cost of watering	045	035	030	025
Total annual cost per square yard of maintaining the pavement	$0 788	$0 525	$0 378	$0 194

For a ready general comparison of results Table No. 32 may be constructed:

Table No. 32.—Comparison of Cost of Various Pavements.

	Classes of Streets.			
	A.	B.	C.	D.
Granite block	$0 586	$0 439	$0 429	$0 358
Sheet asphalt	576	381	328	264
Macadam	788	525	378	194

Explanatory Remarks.

These results are not presented as strictly accurate or conclusive. In the present state of our information they must be regarded as approximate only. All the conditions assumed and used *may* differ in any one city, and are likely to differ in different cities. Emphasis is laid upon the *method* of esti-

mating the economic value of pavements rather than upon the correctness of the data here used. It may, I think, be claimed that the data and results are approximately correct for Boston, and that they represent the best general information available at this time.

The figures given for first cost and cost of renewal represent what, in my opinion, should be the maximum costs in Boston at this time. The actual cost is, and has been for many years, much higher.

The assumed life of the pavements in years represents what should be their *useful* life. There comes a time in the life of every pavement when it will be cheaper to renew it than to continue repairing the old. Pavements are often continued in use long after it would be more economical to renew than to continue to repair them. The above computations assume that the useful life ends when they should be renewed rather than further repaired. The life given in the tables also assumes that the pavements are properly constructed originally and properly renewed when renewal becomes necessary and that they are kept in a good state of repair.

Conclusions.

Referring to Table No. 32 it appears that for Class A streets macadam is the most expensive pavement to use, and that there is a slight difference in favor of sheet asphalt over granite. But other considerations, the principal one being the difficulty and inconvenience of making the frequent and quite expensive repairs that would be necessary to an asphalt pavement on a crowded street, clearly indicate that the granite pavement is preferable.

For Class B streets macadam is also decidedly the most expensive, while sheet asphalt is decidedly the most economical.

On Class C streets granite is the most expensive, and there is a material difference in favor of sheet asphalt over macadam, but the relative cost of the two does not differ very widely.

For Class D streets granite is comparatively very expensive, and macadam is so decidedly the cheapest that if economy alone is considered it merits almost exclusive use.

I have no information as to the relative area or mileage of the four classes of streets in Boston, but the conclusion is warranted that macadam has been used in that city on a much larger scale than economy would dictate.

According to the Annual Report for 1906 the area of each of the several kinds of pavement in Boston was as follows:

Granite block	2,156,076 square yards.
Sheet asphalt	328,105 square yards.
Macadam	6,269,208 square yards.
Wood block	34,379 square yards.
Bitulithic	107,786 square yards.
Brick	3,819 square yards.
Cobble	3,602 square yards.
Total	8,902,975 square yards.

From which it appears that about 70 per cent of all the pavement in the city is macadam.

Some idea of the disproportionate quantity of macadam laid in Boston may be obtained by comparing the above percentage with the percentage of that pavement in a few of the other large cities in the Eastern United States, according to the latest statistics available, as follows:

In New York	36 per cent.
In Philadelphia	14 per cent.
In Baltimore	9 per cent.
In Buffalo	3 per cent.
In Washington	24 per cent.

Table No. 30 indicates that granite block is the most economical pavement only on streets carrying the very heaviest travel. It appears that about 24 per cent of the total area of paved streets in Boston is paved with this material. Considering the objections to this kind of pavement, such as its extreme noisiness and its high resistance to traction, the conclusion is justified that it has been adopted to a larger extent in Boston than is economical or desirable.

CREOSOTED WOOD-BLOCK PAVEMENTS AND BITULITHIC PAVEMENTS.

These pavements have not yet been in use long enough to afford satisfactory data as to their durability or cost of maintenance.

Untreated wood-block pavement has been pretty well tried out and its use abandoned in American cities, not only because of its rapid natural decay, but because its durability under heavy travel has been unsatisfactory. It should be said, however, that it hardly had a fair trial. The wood used was often of inferior kind and quality, it was usually laid on an insufficient foundation and the work was generally not properly done. In European cities it has given better results and is still largely used in some of them, notably in London. The experience and experiments abroad have given us a pretty good idea of its durability under heavy travel, and it may be rated in this respect as decidedly inferior to sheet asphalt.

It is asserted and believed by many that proper treatment with creosote oil not only preserves the wood from natural decay, but greatly increases its endurance under heavy travel. The first claim is undoubtedly true, but the second is not yet proved, and its truth is at least doubtful. It has been determined by careful experiments that the process of creosoting does not increase the strength of wood in any way. It is claimed, however, that the introduction of the oil tends to prevent the absorption of water by the wood, and thus preserves its strength, it being well known that moisture decreases the strength of all woods. There is doubtless some basis for this claim, though recent examinations by me show that creosoted wood-paving blocks, after being in use for a comparatively short time, absorb almost as much water as untreated wood.

In my opinion experience will demonstrate that creosoted wood-block pavement will not prove as durable as sheet asphalt, assuming, of course, that both are properly constructed. The annual cost of repairs will doubtless be found somewhat less for the wood than for the asphalt, particularly during the earlier years of their life. The first cost of con-

struction of the wood pavement is, however, at least 12½ per cent greater, and that of renewal about 15 per cent greater than sheet asphalt for the same class of street (as Class B for instance), and if we assume that its endurance under travel is 85 per cent that of asphalt the annual cost yer yard per year, determined by the method used above, would be about 25 per cent greater than that of asphalt.

The bitulithic pavement is a patented form of bituminous concrete, the cementing material in which is claimed to be a specially prepared coal tar pitch.

In the light of our present knowledge and experience it is not as durable and costs more for ordinary repairs than sheet asphalt.

Its first cost and the cost of renewal should be less than for sheet asphalt. It is not suitable for use on Class A streets, and our present information indicates that for streets of Classes B, C and D it will figure out less economical than sheet asphalt.

BRICK PAVEMENTS.

Brick pavements are extensively used in the interior cities of the country, where good paving brick can be had at reasonable prices. They have not been used in Boston because no material for making suitable brick seems to have been discovered in that vicinity and the high cost of transportation from points where they are produced would make the cost of the pavement greater than its merits warrant.

REMARKS ABOUT COST OF REPAIRS.

A properly constructed granite block pavement requires less repairs than any other, and such repair work as may be needed will nearly all occur toward the end of the useful life of the pavement.

The repairs required will not be due so much to the wear of the paving blocks as to the gradual disintegration of the whole structure by the conditions of city use, principally the frequent cutting into and restoration of the pavement, and other disturbances. Thus on Class D streets, where the useful life of the pavement has been assumed at twenty years, it is not likely that the paving blocks would be worn out at

the end of that period, but the operation of the causes spoken of above would probably make the general condition of the pavement such that reconstruction would be necessary.

On the other hand, sheet asphalt not only requires a larger total expenditure than granite to keep it in good order, but more or less repair work is likely to be needed while the pavement is comparatively new. This fact is likely to create a wrong impression as to the comparative durability of the pavement. This impression has been further fostered by the fact that the contractors are required under a guaranty to keep the pavement in good repair, but fail to do so, and it often, therefore, presents a very disreputable appearance. Where needed repairs are promptly and properly made it is found that the whole cost of repairs, divided over the useful life of the pavement, is not excessive. We have more complete statistics of the cost of maintaining asphalt pavement than of any other kind, and the above statement is fully warranted by the recorded facts.

The cost of keeping macadam in repair depends very largely upon the travel to which it is subjected. On local suburban streets it is very small, while on streets of concentrated heavy travel it is so great as to make the use of the pavement almost prohibitive. The cost of maintenance of macadam streets in Boston is not known, as no satisfactory records seem to have been kept. On the heavy traveled macadam streets of London, where pretty accurate cost-accounts are kept, it is found to range from 40 cents to 70 cents per square yard per year, while in Paris the *average* cost a few years since was over 40 cents per square yard per year.

COST AND FACILITY OF CLEANING.

It is well recognized that some pavements can be kept up to a certain standard of cleanliness at a less cost than others.

The commission appointed by Mayor McClellan to report on street cleaning and waste disposal in New York concluded, after a careful study of all the available information, that if the cost of cleaning sheet asphalt be rated at 100, the cost of cleaning equally well various other pavements is about as follows:

Sheet asphalt	100
Wood-block pavement, new	105
Wood-block pavement, old	125
Brick pavement	120
Granite-block pavement	140
Cobble-stone pavement	300

Since the cost of cleaning may be considered a legitimate part of the cost of maintaining a paved street it is proper to take into account this item of cost in determining the relative economy of the different pavements. Where pavements other than macadam are properly cleaned by sweeping and flushing combined, no watering to keep down the dust is usually necessary. But macadam must be watered or otherwise treated, both to keep down the dust and to preserve the pavement, and the cost of such watering may be properly considered a separate part of the expense of maintenance.

RESISTANCE TO TRACTION.

The resistance that pavements offer to loads hauled over them is another matter upon which we have not the necessary experimental data for satisfactory discussion, except in the most general way.

It may seem a surprising thing that we have no accurate information as to the power required to haul loads over the different kinds of pavement. It is another illustration of the carelessness of municipal engineers in the matter of street pavements. The power required to haul different loads on railroads or by water, under given conditions, has been pretty accurately determined, but little effort has been made to ascertain the power required for or the cost of inter-urban transportation over streets. We rely largely upon some crude experiments made abroad about half a century ago. Based upon these, and a few later experiments, it is generally assumed by modern writers upon the subject, and accepted by modern engineers, that the continuous force required to haul a load of one ton over the several kinds of pavement is as follows:

Over ordinary dirt roads	200 pounds.
Over macadam in poor condition	90 to 140 pounds.
Over macadam in average good condition	33 to 45 pounds.
Over granite block, in poor condition	40 to 90 pounds.
Over granite block, average quality and condition	33 to 45 pounds.
Over wood block	24 to 41 pounds.
Over sheet asphalt	15 to 26 pounds.

It is reasonably certain, however, that some of these figures do not correctly represent the tractive resistance of pavements in American cities. Our American creosoted wood-block pavements, particularly when comparatively new, should not offer any greater resistance to travel than sheet asphalt, while our American asphalt pavements (which are quite different from the European pavements upon which the experiments were made) doubtless require more force than stated above to haul loads over them, particularly in the summer when they are, as now made, quite soft.

The difference in the amount of load which a horse can haul over the different pavements is worthy of careful consideration in comparing the economic values of the several kinds of pavements. Its importance is, however, often exaggerated. The fact that all loads are not full loads, that loads can seldom be confined to traveling over one kind of pavement, and that other conditions, such for instance as steep grades, limit the weight that can be hauled, all tend to modify theoretical conclusions. Allowing for all these, however, it must be apparent that the smooth pavements, asphalt, wood block and bitulithic, must be decidedly more economical for city transportation than granite and macadam.

REPAIRING OPENINGS.

Another element that must be considered is the economy, facility and perfection with which cuts into the pavement can be restored. Repairs of this character make up a very considerable percentage of the cost of pavement maintenance in American cities, though this item of cost is not chargeable to the pavement itself.

In this respect macadam has the advantage, since it can be

opened and restored at a lower cost per square yard than the more complex pavements, and skilled labor is not required. But on the other hand, those pavements having a concrete foundation can be more perfectly restored to their original good condition than can macadam, and the repairs if properly made are more satisfactory and permanent.

HYGIENIC QUALITIES.

The sanitary requisites for a pavement are that it shall be impervious to the absorption and retention of fluids, with the impurities that they contain, and that it must be capable of being properly cleaned. The source of most danger is the germs of disease, the life and propagation of which require the presence of filth, moisture and warmth. The kinds of pavement we are considering, if properly constructed, are quite impervious to water and can be kept reasonably clean. If not kept clean the dust that accumulates is not only a source of discomfort, but is believed to be one of the most dangerous vehicles for conveying germs into the lungs and blood of human beings. Hygiene, therefore, requires that streets be kept, as nearly as possible, dustless. This is most difficult on macadam pavements, and next on granite-block pavements, the rough surface and depressed joints of which serve to retain and protect street dirt.

Street noise is held by some eminent medical authorities to cause and promote certain nervous diseases, and to the extent that this may be true *noiselessness* must be considered a hygienic virtue in pavements. In this respect the wood-block pavement is superior to all others, macadam probably stands next, and sheet asphalt and bitulithic next. Granite is by far the noisiest of all pavements and is a rank offender in that respect.

FOOTHOLD FOR HORSES.

Any pavement with a smooth surface is liable to be very slippery and difficult for horses to travel over at certain times and under certain conditions. A slight fall of snow, say one-fourth inch or less in depth, will make it almost impossible for horses to keep their feet on sheet asphalt and

new wood-block pavements. A thin layer of street slush also lubricates the surface of these pavements and makes them quite slippery.

European rock asphalt pavements (Sicilian and Seyssel) are decidedly more slippery than the American asphalt pavements, which are composed largely of sand, and when perfectly clean, whether wet or dry, afford good foothold. New creosoted wood-block pavement, owing to the oil it contains, is quite as slippery as European asphalt, but after the surface becomes crushed or "broomed" it affords a somewhat better foothold than American asphalt. The bituminous concrete pavements (bitulithic) have a comparatively rough surface and give a satisfactory foothold under most conditions. Granite-block pavement is less slippery than the pavements named above, particularly while comparatively new, and macadam is, in this respect, the most satisfactory of all.

Where the streets are kept reasonably clean the smooth surface pavements are not objectionably slippery except for short periods at comparatively rare intervals, and their lower tractive resistance at all times more than compensates for their occasional slipperiness. If the European practice of sanding pavements when conditions make them slippery were introduced and followed here, it would practically remove this objection to smooth pavements.

COMFORT AND CONVENIENCE IN USE.

The qualities that contribute to comfort and convenience in the use of pavements are smoothness, noiselessness, cleanness and good appearance. The importance to be attached to these qualities is largely a matter of opinion and their value as compared with other qualities are rated very differently by different persons. There is undoubtedly a great difference in the personal comfort to any one of riding over smooth pavement, like wood block, sheet asphalt, macadam and bituminous concrete, and of riding over granite blocks. The extreme noisiness of granite-block pavement is a source of real discomfort and inconvenience to persons living or doing business along a street paved with that material.

The smooth paved streets undoubtedly present a better appearance than a granite block street.

While no definite value can be placed upon these qualities they deserve consideration in the problem of selecting the pavements to be used.

GENERAL CONCLUSIONS.

Taking into consideration the relative economy of construction and maintenance, as well as the other factors in the problem, named above, which must be given their proper weight, my conclusions are that in the future selection of pavements for the streets of Boston the following general project should be followed:

1. For streets in the heart of the city, and about markets, railroad stations, wharves, etc., where the travel is of great volume and of the heaviest character, granite-block pavement should continue to be the standard. No other kind of pavement now in use will so well or so economically meet all the conditions on such streets.

2. For all secondary business streets where the travel is moderate both in volume and weight, and for the main driving thoroughfares of the city and suburbs, sheet asphalt pavement should be adopted as the standard. For this class of streets it is not only most economical, but it possesses in a high degree most of the other qualities desirable in a roadway pavement.

If it shall be developed in the future that other pavements, such as creosoted wood block and bituminous concrete, can be constructed and maintained at a cost that will make them practically as economical as sheet asphalt, their superior qualities in a few points would dictate that they should share with sheet asphalt employment on this class of streets.

3. For all suburban streets, and for many purely local streets in the interior of the city, where the travel is light, macadam should continue to be the standard, at least until some satisfactory substitute shall be developed.

For this class of streets no other pavement is nearly so economical, and if properly constructed and cared for it possesses many of the other qualities desirable for local and residence streets.

These conclusions are, of course, general in character. Conditions and circumstances may make it advisable to vary from them in many individual cases. It will doubtless be found that in wealthy residence localities there will often be a strong demand for some of the more costly smooth pavements, instead of macadam; and where the improvement is to be mainly paid for by special assessments on the property, such demands might well be complied with.

It will be remarked that these recommendations, if carried out, would result in a very large increase in the use of sheet asphalt pavement, and would in fact make it in time, next to macadam, the prevailing pavement in the city. In my opinion it should be so. I am fully convinced that, all things considered, it is the most economical, and, on the whole, the most desirable pavement for city streets of the classes for which it is here recommended.

The failure of contractors to properly maintain it, under guaranty clauses in their contracts, has undoubtedly created a sentiment in the public mind, in Boston as well as other cities, unfavorable to the pavement. This is the fault of the contractors under the present system of guaranty maintenance by the contractors who, mistakenly, as I believe, consider it to their interest to spend no more money for repairs than they are compelled to do by the city. As remarked above, this pavement undoubtedly requires more repairing in the earlier years of its life than others, and requires more care and attention at all times, though, if properly cared for, the aggregate cost of maintenance is not nearly so great as the public has been led to believe.

REMARKS AND SUGGESTIONS ON PAVEMENT CONSTRUCTION AND MAINTENANCE IN BOSTON.

In dealing with this branch of the subject it is not possible to undertake anything like a full and connected treatment in this report. It will only be attempted to call attention briefly to some points in which the present practice in Boston seems to me to be wrong or capable of improvement.

Designing Roadway Pavements.

In almost every branch of engineering the theory and practice generally adopted of designing structures for public utility is as follows:

The purpose of the structure and the work that it will be required to perform are first investigated and determined. Thus, if the structure be a proposed bridge, the character and quantity of the travel it must accommodate, the loads it must carry, and the conditions under which it must be constructed are all investigated.

This having been done, the structure and all its details is carefully designed to perform safely and satisfactorily the work that will be required of it, and no more. It is treated as an individual structure to meet certain predetermined requirements in the most economical way.

But in the paving of our streets this obviously logical and proper procedure is hardly ever followed. In the great majority of cities standard plans and specifications for a given kind of pavement are prepared and used, requiring fixed dimensions and materials of a certain character used in a certain way. These plans and specifications are applied to the construction of every pavement of the kind indiscriminately, regardless of the actual requirements of the street. In many cities if a granite-block pavement, for instance, is determined upon, the standard specifications are applied whether the street be one of heavy or of light travel, and regardless of other differing conditions. The result is that the pavement may be inadequate on some streets and needlessly heavy and, therefore, needlessly expensive on others.

The proposition that street pavements should be designed and constructed like other engineering structures with reference to the work that will be required of them is so obviously true that it needs no argument or further illustration.

Standard *forms* of plans and specifications are desirable and possible, but they should admit of such elasticity as will permit of varying dimensions, materials and methods of construction. Dimensions which it may be desirable to vary on different streets may be left blank in the printed forms, to be filled as required, and several such printed forms may

be necessary, covering different materials and methods of construction. To illustrate: In Boston the concrete foundation for sheet asphalt pavement seems to be made, invariably, six inches thick — that dimension being printed in the specifications and apparently never changed. This concrete foundation is a very important part of the pavement; it must be strong enough to rigidly support the asphalt surface, but it need be no stronger. Where the pavement is laid on streets of very heavy travel, particularly if the underlying sub-foundation is more or less unstable and yielding, the thickness of the concrete should be not less than seven inches. On the other hand, where the pavement is used on suburban streets of light travel, and the sub-foundation is sound and firm, experience has shown that the thickness of the concrete may safely be reduced to four inches. Where four-inch concrete is adequate it is obviously a waste of money to make it six inches thick. Not only may the *thickness* of the concrete be varied with the varying conditions, but its *composition*, as the ratio of cement used, may be advantageously varied.

So, also, with the asphalt surface. On some streets one and one-half inches of binder and two inches of surface proper are none too heavy, while on others one inch of binder and one and one-half inches of surface is ample.

If care were thus taken to design pavements carefully with reference to the work required of them, instead of constructing them all in accordance with one pattern, it would undoubtedly result in the saving of large sums of money in any city. Not only is it wasteful to make pavements unnecessarily expensive, it is equally poor economy to make them lighter than the service required of them demands.

Pavement Foundations.

Pavements, like any other structures required to carry weight, must have adequate foundations. This fact seems to be often overlooked or neglected, not only in Boston but in many other cities. It is a sheer waste of money to construct an expensive pavement on a yielding foundation that will give way and allow the pavement to be destroyed in a few years, or

to be so greatly injured that extensive and costly repairs, if not reconstruction, will become necessary. Examples of this may be seen in Boston. Some of them are due to the application of fixed standard specifications to cases where a different construction was clearly required.

On streets located over built-up or soft, yielding ground, a broken stone foundation should never be relied upon to support a permanent, high-priced pavement. A concrete foundation course of sufficient depth and strength is required, and if this cannot be provided it is better to pave the street temporarily with macadam. Settlements may, in this way, be more readily and cheaply repaired by filling in additional stone, and in time a secure foundation for a permanent pavement may thus be created.

Concrete is the only satisfactory foundation course for all pavements on streets of heavy travel, whatever may be the kind of pavement used (excepting macadam). It is a mistake to use a broken stone or gravel foundation under granite blocks on such streets, as is now the practice in Boston. The difference in cost between a foundation of six inches of broken stone and one of six-inch concrete should not exceed 35 cents per square yard at present prices of materials in Boston, and this additional cost would be more than repaid by the greater durability and lower cost of maintenance of the pavement.

Sheet asphalt and wood-block pavements should always be laid upon a concrete foundation, but its thickness and composition may be varied as the character of the street and other conditions may dictate.

Rigid rules cannot be laid down in the matter of pavement foundations beyond the general ones that they must be of ample strength and should be designed to meet the individual conditions of each street.

SPECIAL SUGGESTIONS RELATING TO THE DIFFERENT PAVEMENTS.

Granite-block Pavements.

Boston has some excellent granite-block pavements and as a rule the work of this class has been well done.

I have expressed the opinion that this kind of pavement

should be used on streets of the heaviest travel only, and that where so used the blocks should be laid upon a concrete foundation. Six inches of concrete would usually be sufficient, but where the sub-foundation is built-up material, or soft and yielding, the thickness of the concrete should be increased to not exceeding eight inches. Where streets of Class B (see classification on page 199) are paved with granite the concrete foundation should still be used, but its thickness may be less, though not under four inches. Four inches of concrete makes a much stronger and more satisfactory pavement foundation than six inches of broken stone, and should not cost over 12½ cents more per square yard.

In my opinion the joints between the blocks should always be filled with Portland cement grout rather than with gravel and pitch, or gravel alone. The grout makes the pavement practically monolithic, greatly increasing its strength and preventing to a great extent the chipping off of the corners of the blocks, which in time makes their tops rounded or "turtle backed." Grout is stronger and resists wear better than pitch and gravel, and joints filled with it do not become dug out to so great a depth, thus insuring a less rough pavement and facilitating cleaning. Grout-filled joints are also impervious to water, which is not true of joints filled with gravel alone. These latter should never be used. Grout-filled joints have been used in Boston to some extent, but have been, I believe, abandoned because they are thought to make the pavement surface more slippery. While joints thus filled undoubtedly make a pavement of more even surface, I do not believe that they materially diminish the foothold for horses. If, however, the objection is found to be valid it can be removed by filling the joints with the grout to within, say, one half-inch of the top, or by removing it to that depth before it sets with a suitable tool, as is done with the joints of masonry.

While the standard depth of blocks used in Boston (seven and one-half to eight inches) may be advisable for streets of the very heaviest travel, a depth of six to seven inches would be entirely sufficient on the great majority of granite paved streets. Blocks of this depth should cost somewhat less in

the market, and the cost of transportation and handling would also be reduced. Blocks of this depth are the standard in a number of American and European cities, while in many of the latter still shallower blocks are largely used.

While the blocks used in Boston are generally of good shape and fairly well dressed, they would be improved if more care were given to dressing them, particularly on their sides and ends, so that narrower joints could be secured in laying them. Stone block pavements with narrow joints wear down to a more even and satisfactory surface than those with wide joints.

Wood-block Pavements.

What has been said about the foundation for other pavements applies with equal force to those of wood blocks. A firm and unyielding foundation is especially important, and concrete should always be used.

There has been much discussion recently as to the proper depth of wood paving blocks. In my opinion the standard adopted in Boston and a number of other American cities, three and one-half inches, is insufficient for streets of heavy travel. I have before me as I write samples of creosoted yellow pine paving blocks taken up from the intersection of Liberty and Greenwich streets, New York, about two years after the pavement was constructed. The blocks were originally three and one-half inches in depth; they measure now two and fifteen-sixteenths inches in depth, but only two and five-eighths inches of the remaining wood is sound and uninjured, as the top five-sixteenths inch is so battered or "broomed" by the travel that its strength is almost wholly destroyed. If we call the average depth worn away three-quarters of an inch, the loss is at the rate of three-eighths inch per year. At this rate not more than one and one-half inches of wood will remain at the end of the sixth year of the pavement's life, and it may be expected that before that time the short blocks will begin to split up and the pavement to disintegrate. (The travel at the point named is unusually heavy — probably exceeded by very few streets in any city.) It seems clear to me that these blocks should have been not less than five inches long originally, and six inches would have

been better. Judging from this case and from the accumulated experience in foreign cities, it is my opinion that for heavy traveled streets in Boston the blocks should be not less than five inches long. The depth now used, three and one-half inches, may be sufficient for Classes C and D streets, but I would prefer to have them not less than four inches long. In London, where wood-block pavement is used on streets carrying heavy travel, the blocks are from five to seven inches deep.

Wood paving blocks should be carefully inspected, and this can be done only before they are creosoted, since the treatment in oil may hide important defects. Several species of wood are suitable for paving blocks. Heretofore long leaved yellow pine has been principally used and probably has no superior for the purpose, but its present high price makes it very expensive. As it now appears on the market the lumber contains a large percentage of inferior pine, such as short leaved and bastard pine, and it requires a skilled inspector to distinguish between them. Black gum is now being used for paving blocks and seems very suitable for the purpose. It requires a skilled inspector, however, to distinguish between the true black gum and the very inferior Tupelo gum, the cheapness of which tempts dealers to substitute the one for the other.

Specifications for wood-block pavement usually require that the blocks be set in a bed of Portland cement mortar one-half inch deep. In practice the sand and cement are frequently only moistened into a damp powder, which is not mortar, nor does it serve the purpose as well as mortar. In the Boston pavements which I saw in progress this dampened powder was being used. The use of mortar should be insisted upon, as called for by the specifications.

Asphalt Pavements.

The asphalt paving business has always been conducted upon a different basis from other city paving work. It was originally promoted by a few companies or corporations who practically controlled, by franchises, leases or contracts, the only asphalt that was then believed to be suitable for making

what may be called American sheet asphalt pavements. The proper composition of this pavement, being artificial as compared with the natural rock asphalt of Europe, and the proper construction of the pavement on the streets, required special skill, which was for a long time confined to a few persons and companies. All these things combined to keep the control of the business in a few hands. Later, other natural bitumens were discovered or put upon the market which it was found would make pavements practically as good as the Trinidad asphalt, though requiring somewhat different compositions and handling on the street.

Attempts, later, to control the supply of asphalt and the asphalt paving business by the formation of combinations or "trusts" have been only partially successful. At present there are a number of companies engaged in the business that are outside the "trust," but between the more important of them and the "trust" there is believed to be a "community of interests," the tendency of which is to keep up prices, in a few cities at least. This is, undoubtedly, the case in Boston.

During most of the period covered by the development of the asphalt pavement in this country more or less European rock asphalt has been imported and laid into pavements in a few American cities. While pavements of this material are equally as durable as those made with American asphalts, they are decidedly more slippery, and the higher cost of the material makes it now impossible to compete in price with the American article except in a few cities where high prices have been maintained. In the great majority of American cities it may be said that the European rock asphalt can no longer successfully compete with American asphalt. This fact, together with the fact that the quality of the American asphalt pavements has been greatly improved in the last decade, probably indicates that European rock asphalt pavements will not be laid in this country to any considerable extent in the future.

The fact that considerable capital, an expensive plant and skilled men are required to properly conduct the business of constructing asphalt pavements tends to confine the busi-

ness to a few strong companies or persons, and to that extent eliminates the wide competition found in other lines of street paving. The practice that has prevailed of requiring long and onerous guaranties upon the new pavements has also tended to keep the business in the hands of a few strong contractors.

One important change has, however, taken place in the business in the last ten or fifteen years. The knowledge of how to construct the pavement in the best manner, and the skill to properly do the work is no longer confined to the contractors and is procurable by municipalities and others.

Formerly specifications for this work were practically dictated by the contractors, as the municipal engineers had not themselves and could not readily procure the technical knowledge and skill required, and the contractors were given a free hand in doing the work.

This practice of following the contractor's specifications and allowing him to dictate how the work should be done on the street was further fostered by the requirement of a long-time guaranty on the work, since it was felt that if the contractor was required to produce a specified result he must, logically if not legally, be permitted to exercise his own judgment and methods as to how that result should be attained.

The present situation in the asphalt paving business may be briefly summed up as follows:

Several American asphalts suitable for paving purposes are on the market, controlled by different interests, so that there is no monopoly in the supply. Among these asphalts may be named that from the Island of Trinidad, that from the State of Bermudez, Venezuela (known as the Bermudez asphalt), that from the vicinity of Lake Maracaibo, Venezuela, and the residual pitches resulting from the distillation of the asphaltic oils of California.

There are a large number of contractors outside of the "trust" now engaged in laying asphalt pavement. But where the actual or prospective quantity of work in any city is comparatively small, outside contractors are not very likely to become competitors of the local contractors,

because of the large general expenses that must be incurred in erecting the plant, etc., and doubtless sometimes because of "community-of-interest" understandings.

The technical and practical knowledge necessary to specify and direct the construction of good asphalt pavements is no longer confined to a few contractors. City engineers, if not themselves qualified, can procure the advice and assistance of experts, so that they can efficiently design and control the work.

The practice of requiring long-period guaranties on the work is coming into disrepute, and where they are discontinued there can be no longer a pretext that the contractor must be allowed to dictate how the work shall be done.

The knowledge and art of constructing asphalt pavements has made important advances. Pavements of this kind laid now by responsible contractors are undoubtedly superior to those laid a few years ago. At the same time improvements in plant and in methods of doing the work have reduced the cost to the contractor, so that prices should be lower now than heretofore.

In view of this situation I would recommend that the future construction of these pavements in Boston be conducted in accordance with the following program:

1. That complete and adequate specifications be prepared and adopted.

2. That all proposed work be advertised and that contracts be awarded to the lowest responsible bidder, subject to the condition named in 4.

3. That the guaranty period be reduced to two years.

4. That the City Engineer prepare or have prepared estimates of the actual cost, plus the usual allowance for contingencies, plus a reasonable profit to the contractor, of asphalt pavement constructed in accordance with the specifications, under the various conditions that are likely to occur, and that no bid shall be accepted unless it shall be below, or shall not exceed by more than 5 per cent, the said estimates.

5. That contractors be held to a full and strict compliance with the requirements of the specifications.

As these recommendations involve radical departures from present practice in Boston, they may be briefly explained and discussed.

The general subject of specifications will be discussed later in this report. Specifications for asphalt pavement, under the program here recommended, should adequately dictate the quality of the materials to be used and the manner in which the work shall be done in all its details, and they should be strictly enforced. This being done, the city and its engineer should accept responsibility for the results. In effect, this means that contracts for constructing asphalt pavements shall be put upon the same footing as those for other kinds of pavement.

Inasmuch as competition not only between different contractors, but between different asphalts, is to be encouraged, and since the different asphalts require different technical and practical treatment, separate alternate clauses or provisions, appropriate for each, should be provided in the specifications.

In stipulating that contracts should be awarded to the lowest responsible bidder it is intended that the word responsibility shall embrace, in addition to financial responsibility, knowledge and experience in this particular work and reputation for complying with obligations and for honorable business methods.

I have long believed that the practice of requiring long-period guaranties upon any kind of paving work is unwise and derogatory to the best interests of the municipality. Recently, this conclusion is being accepted by many city authorities and engineers, and the tendency is to abandon these guaranties in new contracts, or to confine them to short periods. A general discussion of the subject is hardly practicable here, but such a discussion will be found in chapter XI. of my book, "Municipal Public Works," published in 1903.

The adoption of limiting prices within which bids must fall to be acceptable is entirely practicable and it offers a good means of defence against exorbitant prices, whether they result from combinations among bidders, from obliga-

tions of contractors to pay improper commissions, or other causes. The device is not new. It has been in use in Washington for many, and in New York for several years, and has been effective. Its principal danger lies in fixing the limit unreasonably low. The contractor is entitled to a price that will, first, cover the actual cost of doing the work in a proper manner, including legitimate general expenses, such as interest, depreciation, general supervision, etc.; second, to a reasonable profit on the work, and third, to an allowance for unforeseen or contingent expenses, which will vary with the character of the work. In paving work it should not exceed 5 per cent of the estimated cost.

It is possible for a city engineer having a good knowledge of the business to arrive at what is a fair and just price and to fix a limit accordingly. He should be as careful not to make it too low as to make it too high. If the limiting price be made too low there is danger that contractors may shape their bids to meet it, and may later plead inadequate compensation as an excuse for poor work or as a basis for asking that the specification shall be less rigidly enforced. This has occurred in at least one city, where lax supervision by the engineer has allowed contractors to do poor work.

I would recommend that hereafter the period of guaranty on all asphalt pavements be reduced to two years.

In the case of standard pavements that have been in use long enough so that their endurance and other characteristics are well known, the only legitimate object of a guaranty is to provide against such defects of construction as may be overlooked at the time, and which the contractor may be reasonably expected to remedy.

Maintenance of Asphalt Pavements.

It is undoubtedly true that an asphalt pavement is likely to need repairing earlier after its construction than granite-block or wood-block pavements, and that it requires a greater degree of skill and more prompt attention to keep it in good condition. The secret of maintaining this pavement economically lies in repairing defects as soon as they appear. A small hole in the surface that may be repaired at once for

a few cents may, if neglected, increase in area rapidly, so that in a few months it may cost as many dollars. While this fact is recognized by contractors for maintenance, whether under a guaranty or a separate maintenance contract, they are inclined to postpone needed repairs until enough such work accumulates to warrant them in starting up their plant (which is ordinarily designed for construction work only, and not adapted to doing small repair work economically), and in putting a correspondingly large force on the streets. This disposition on their part should not be tolerated; they should be compelled to make all needed repairs promptly and properly.

To enforce the orders to do this it may be necessary, and is, I think, desirable that the city shall have a small repair plant, so that in case the contractor is tardy the Street Department may be prepared (as it is authorized to do in most contracts) to itself do the work, in which case the contractor should be charged with the whole cost, plus a liberal percentage for profit.

In an article published in "Engineering News," May 9, 1907, I considered this matter of repairing asphalt pavements in some detail, and I may refer you to this instead of taking up the matter at length here.

Macadam Pavement.

Macadam is the simplest of all pavements to construct, and the proper materials and methods of doing the work are well understood. As a rule this work seems to be well done in Boston. On streets of comparatively heavy travel the thickness of "metal" (broken stone) should be eight or nine inches, instead of six inches, which I believe is now the standard thickness in Boston.

It is the custom in Boston to pave the gutters on macadam streets with granite blocks. Granite gutters are preferable to none or to extending the macadam out to the edgestones. But these granite gutters are objectionable on account of the roughness of their surfaces, which obstruct the free flow of water, serve to retain dirt, and are not readily or effectively cleaned. A properly constructed *concrete gutter* would be

much better, and would be at least as durable as the granite gutters as they are now constructed. At present prices of labor and material in Boston these concrete gutters, made 2½ feet wide, should not cost more than 50 cents per linear foot of gutter. The granite gutters now used, having gravel joints, seem to cost about 17 cents per linear foot where the city supplies the granite blocks, which, if charged at 2 cents each, makes the cost about 37 cents per linear foot. If the joints were filled with Portland cement grout, as they should be, the cost would be further increased to about 47 cents per linear foot of gutter. The superiority of the concrete gutter would, in my opinion, more than compensate for its slightly greater cost.

The present practice of setting the granite blocks (in gutters) upon a bed of gravel, and of filling the joints with dry gravel is objectionable. The gravel joints must, especially when the gutters are new, permit the gutter water, charged with street dirt, to pass down quite freely to the gravel foundation, and all the gravel must, in time, become filled with street dirt and filth, rendering these gutters unsanitary.

Furthermore, it is to be expected that the water reaching the gravel foundation will, in some cases, create currents, particularly where the street grades are steep, that may wash out or disturb the gravel and allow the paving blocks to settle, thus injuring the gutter.

If granite gutters are to be used the joints between the blocks should be filled to the top with Portland cement grout. Not only would this make the gutter stronger and more durable, but it would make the joints impervious to water, and the surface of the gutter less rough and uneven, thus facilitating the rapid and complete flow of water, as well as decreasing the quantity of dirt retained by the gutter.

Hydraulic Concrete Roadway Pavement.

Two or three short stretches of street in Boston have been paved with a patented form of concrete pavement called Hassam pavement, the use of which on streets of any considerable travel is so far purely experimental.

I believe that a very good and economical pavement for

streets of moderate travel can be made of hydraulic concrete properly made and applied. It would be suitable for the heavier traveled streets of Class D, for which macadam is herein recommended.

Such a pavement would be much more durable, much less *dusty*, and would not cost materially more than a properly constructed macadam road.

I recommended some years since a careful trial of such a pavement, and prepared outline specifications which called for a four-inch foundation course of ordinary concrete, such as is used for other pavement foundations, covered with a two-inch wearing course of concrete of special composition and preparation. This surface course could be renewed when necessary. I believe that this pavement would prove at least as durable and satisfactory as the patented Hassam pavement, and it can be constructed at less than two-thirds the price paid in Boston for the Hassam pavement.

Bituminous Concrete Pavement.

One of the chief objections to macadam pavements is its dustiness in dry weather. The dust is not only a source of great discomfort to people using or living along the streets, but it is destructive to the clothes of travelers and to various articles of household furnishing where it is carried into residences by the wind. Dust is also believed to be promotive of disease, not only by its physical injury to the lungs, but by carrying disease germs into the human system.

The remedy against dustiness has heretofore been to keep the surface of the street damp by watering, which also conduces to the greater durability of the pavement. At present, the use of various oils and tars to keep down the dust is being quite largely tried with good success. The most serious objection is its cost. Effective treatment by this method seems to cost from 12 to 15 cents per square yard per season, while sprinkling with water should not cost, including the value of the water used, more than 4 cents per square yard per season. Taking the lower cost of oiling as given above it costs about 8 cents per square yard per season more than watering. This sum capitalized at 4 per

cent is $2. It is, therefore, an important question whether it might not be more economical and satisfactory to expend a larger sum in original construction if thereby a pavement could be secured that would generate little dust, which could be satisfactorily kept down by moderate sprinkling with water. In other words, the question is whether it would not be cheaper and better to construct, at first, roads and streets that would be comparatively dustless than to attempt to get rid of the dust by oiling. This question has been studied in England, where road oiling and other dust palliatives have been used quite extensively, and it is recently stated as the conclusion there that the solution of the problem must be found in the construction of dustless roads rather than in means of laying the dust after it is produced.

Much attention is being given, both in this country and abroad, to investigations and experiments to discover and develop a comparatively dustless road that can be constructed at a cost not greatly exceeding that of macadam. The trend of opinion is to the effect that the problem may be solved by a comparatively cheap form of bituminous concrete. The best and cheapest construction has not yet been developed, but it will probably be found in something like the following: The road will be constructed in two courses, the first or foundation course being practically a four-inch macadam road, as now constructed, except that a smaller quantity of binding material (stone screenings) will be used upon its surface. Upon this foundation course will be placed a wearing course of bituminous concrete. The best composition and method of making this surface course is yet to be determined, but it will probably be found in a mixture composed of the best trap rock, crushed so that all will pass through a 1½-inch screen, the voids in which are to be filled with stone screenings of the same material of assorted sizes, containing but a moderate percentage of very fine particles, usually called dust. The mass of stone so composed will then be mixed with sufficient bituminous cement to slightly more than completely coat each particle of stone. The cement will be melted and heated and mixed with the cold stone, on the street, using a suitable mechanical mixer. This mixture will then be

applied to the foundation course and thoroughly rolled, its thickness after rolling to be from 2 inches to 2½ inches as the travel may require.

The bituminous cement best suited for the purpose is yet to be determined. It will probably be found in coal tar pitch mixed with some variety of asphalt which melts at a comparatively high temperature, but the mixture must be of such consistency that it will flow quite freely at moderate temperatures, in order that it may be satisfactorily mixed with the cold stone.

I believe it may be safely predicted that the coming pavement for streets of light travel (Class D) will be constructed along the lines outlined above, and that a street surface will thus be developed that will be comparatively dustless, will be materially more durable than the best macadam, will give excellent service in use, and the cost of which will not exceed that of properly constructed macadam by more than from 25 cents to 50 cents per square yard.

I would strongly recommend that developments along this line be carefully watched and that experiments on a small scale be made by the city.

The oiling of macadam roads has not yet passed the experimental stage. I have no doubt that dust can be thus prevented and the life of the pavement materially prolonged, but to produce satisfactory results it will probably be found that larger quantities of oil than are now generally applied must be used, and that when this is done the cost will be found too great to make the method economical. In any event the proper direction of effort should be toward the creation of dustless roads rather than toward dealing with the dust after it is produced.

INCIDENTAL MATTERS.

Plans and Specifications.

The plans and specifications for any public improvement should be a full and sufficient guide to the contractor who undertakes to do the work. They should set out clearly and unmistakably the nature and extent of the work to be done, the character and quality of the materials to be used, the way

in which these materials are to be fabricated, the methods and processes to be followed, and the degree of perfection that will be expected and demanded in the finished product. They should be so clear, exact and definite that their meaning shall not only be obvious, but they shall admit of no interpretation other than that intended. They should set up definite requirements and standards rather than general terms that are subject to various interpretations or may be matters of opinion. Instead of such stipulations, for instance, as that materials shall be "the best of their kind" or "of a quality satisfactory to the superintendent." The qualities required should be set out in definite terms.

The specifications for street improvements now in use in Boston are very incomplete and defective. I know of no city of considerable size in the United States whose specifications for street paving are so inadequate and open to so much adverse criticism.

Without undertaking to review them generally some illustrative examples may be given.

The specifications for hydraulic cement are so indefinite that a contractor cannot know just what he will be expected to supply. If one will compare, for instance, the specifications for Portland cement in the Columbus avenue contracts of 1906 with those adopted in 1904 by the American Society for testing materials, now generally accepted as a standard, the wide difference between the two in definiteness will be very apparent.

The Boston specifications for Trinidad asphalt pavement may also be instanced. These specifications are wholly inadequate. In many respects they are antiquated, indefinite and wrong. It is safe to say that, fortunately for the city, no recent asphalt pavement constructed in Boston has pretended to comply with them. No proper standards are set up for the quality of the materials to be used. Many important details seem to be left entirely to the judgment or pleasure of the contractor. If some of the requirements were complied with by the contractor the result would be an inferior pavement. For instance, it is stated that the sand used (a very important constituent of the paving mixture) is required

to be of such sized grains that none of it will pass through a No. 80 screen, while in the best modern practice it is considered important that about one-quarter of the whole should pass that screen and one-eighth of the whole should pass a still finer (No. 100) screen. Again, it is now recognized as important that the pulverized carbonate of lime should be very fine; at least 70 per cent of it should pass through a No. 200 screen, while only from 10 per cent to 15 per cent should fail to pass through the No. 100 screen. The Boston specifications require that only 15 per cent of the whole should be fine enough to pass the No. 100 screen.

Similar examples might be multiplied, but it is unnecessary. Upon the whole, however, the sins of omission are more numerous and important than those of commission. They lack completeness, and on many important details they are ambiguous or entirely silent.

The first effort toward any satisfactory reform of the street paving business in Boston must, therefore, be the revision of the specifications for such work.

Where public work is to be carried out by contract, contractors must know in advance fully and explicitly what they will be expected to do in order that they might submit intelligent bids; and when they have, with such full knowledge, submitted proposals and entered into contract, they may and should be held to strict performance. The plans and specifications for the work are the official expression of what will be required and no pains should be spared to make them as complete and specific as possible.

SPECIAL ASSESSMENTS FOR STREET IMPROVEMENTS.

Certain phases of the method and practice of assessing the cost of pavements on abutting property owners in Boston attracted my attention early in my study of the situation there, and at my request considerable data was collected relating to the matter.

I understand that you do not care for a special report upon that subject, but I think some general remarks relating to it are pertinent in connection with the matter of this report.

Street improvements made at the expense of the municipality are justified upon the ground that they are required for the benefit of the public at large. Where such improvements benefit private persons only and not the public at large they should not be paid for by the municipality. If the public and the individual owners of property are both benefited it is right that the cost should be divided between them in the ratio in which they are thus benefited. The truth of these general statements is obvious and may be accepted without further discussion. The whole theory of special assessments rests upon their acceptance as sound principles.

But in putting them into practical operation difficulties arise in determining whether a given improvement is wholly for the benefit of the public or wholly for the benefit of individuals, or partly for the benefit of each, and if the latter, the relative benefit of the improvement to each. It is natural that individual property owners should try to have their personal interests served at the public expense; it is the duty of the municipality to prevent it.

Through personal or political influence, aided by laws not clearly framed in accordance with the basic principles named above, many cities are every year saddled with the cost of laying out and improving streets which are of no benefit whatever to the general public, while they enhance very largely the value of the property of one or of a few private individuals. Take, for instance, the case of a tract of unimproved land lying between two parallel existing streets already connected by a sufficient number of cross streets to afford all needful connections. The owner of the tract finds that by constructing another cross street he can make the property available for building lots which he can sell at advantageous prices. The new street is not needed by and will not benefit the public to the value of a single dollar, and there is no just reason why the municipality should contribute a dollar toward paying the cost of it. And yet numerous cases may be pointed out where the City of Boston has paid the greater part of the cost of such purely private improvements.

It is sometimes argued that a city may, by thus opening up new streets, partly or wholly at its own expense, promote investments and improvements that will so enhance the taxable value of the abutting property that the cost will be repaid to the city in increased taxes. Even if this were true the transaction must be regarded as purely commercial, and the city would be justified on the same grounds in subsidizing manufactories and other private enterprises, or in buying and selling merchandise at a profit.

Most such private street improvements would probably be made by the persons interested without the help of the city, but if they did not promise to be sufficiently profitable to warrant the owners in doing this the city could not hope to be reimbursed from the proceeds of taxation alone.

In the great majority of cases, of course, the public is more or less legitimately benefited by street improvements, and to the extent so benefited should pay a share of the cost. But the authorities, upon whom rests the duty of determining how much should be paid by the city and how much should be specially assessed against the private persons benefited, should be untrammeled in exercising their judgment. In Boston they are not. Under the present law (see section 5 of chapter 393, Acts of 1906) the Board of Street Commissioners are empowered to assess against abutting property owners not more than one-half of the whole cost to the city of a street improvement.

It is true that the board has full and exclusive power to determine whether or not a street shall be improved, and may refuse to make an improvement where, in its judgment, the public will not be benefited to the extent of at least half the cost. Judging from a large number of cases that have come to my attention they do not seem to exercise this right very freely, and as a result the city has paid a large part of the cost of street improvements that were not needed by the public interests, and the benefits from which have accrued almost wholly to private persons or corporations. In other words, the present system of special assessments for street improvements is used by private interests for their own personal benefit, and I have no doubt that

the city pays out in this way large sums of money every year that is not a proper charge against the municipality.

Furthermore, the present law, if enforced strictly and in accordance with the principles outlined, may be a source of inconvenience, if not an actual injustice, to owners of property who want a street improvement made and are willing to pay for it. Such owners may, with the permission of the board, construct driveways at their own expense, but it is desirable for many reasons that such improvements should be made under the authority and direction of the city, thus giving the improvement official sanction and standing. But the Board of Street Commissioners cannot authorize or order the improvement unless they feel justified in charging at least one-half the cost to the city. I think it not unlikely that the board, in cases where it seems important that an improvement should be made under the authority of the city, may thus be influenced to order it, even though they would not otherwise feel that the city should pay half the cost.

For these reasons it seems to me important that the present law should be amended so as to authorize the Board of Street Commissioners to assess *any part* or the whole cost of a street improvement against the private property benefited thereby, in accordance with their judgment.

The amended law should also clearly define the conditions under which the city may be called upon to pay a part of the cost of any improvement, and I think these provisions should follow the principles stated at the beginning of this article; that is, that street improvements should be paid for by the city only when and only to the extent that the public at large is benefited by the improvement. Such an amended law properly enforced would undoubtedly save the city a large sum of money every year.

The present law seems to confine the authority of the Board of Street Commissioners to such highways as may be "laid out, relocated, altered, widened, discontinued or constructed." They apparently have no control over the reconstruction or repaving of a street where no change in location, grade or width of the street is involved, and therefore presumably have no authority to assess property owners benefited.

In this respect the practice of Boston is the same as that of many cities. But it is, in my opinion, wrong. A street may be originally paved with macadam and a due part of its cost assessed against benefited property owners; later it may be found advisable to repave the street with a more expensive pavement. The excess in cost of the last pavement over that of the first is not chargeable to maintenance but to betterment — it is so much additional capital invested in the improvement. In so far as this increased investment may benefit private property it is permissible and just to assess it upon the owners in the same way as a part of the original cost was assessed.

In a number of cities where the cost of *repaving* is not assessable against the property owners, and where the kind of pavement to be used is determined by petition of the abutting property owners, it is notoriously the custom to petition for the cheapest possible pavement, even where a more permanent and costly one is clearly needed. The assessment on the property owners for the cheap pavement is small, but this pavement soon wears out, and then the city must repave with the more expensive pavement, clearly needed at first, wholly at its own cost. The result is obviously an injustice to the city. It is not possible to duplicate such transactions in Boston because the property owners do not dictate the kind of pavement to be used, but the same injustice results to the city where an expensive repavement follows an original one that cost much less.

An effective remedy for all these abuses would be provided if the body whose duty it is to authorize street improvements and make assessments therefor were given full authority, without restrictions (except the usual appeal to the courts), to assess benefits resulting from street improvements wherever and to whatever extent they may be found against all the parties interested, including the city, and were forbidden to authorize any improvement where the sum of the benefits thus found did not exceed by at least 25 per cent the estimated cost of the improvement. This would place the city on an equal footing with the other interested parties. If, further, the assessments were each stated in terms (say per-

centages) of the total cost, the city could not be called upon after the work was completed, as it is now, to bear an undue part of the cost.

Such radical changes in methods would, of course, require new legislation, which I think the interest of the city urgently demands.

My limited inquiry into the matter convinces me that a full investigation would show that the city has been made to pay enormous sums in the aggregate for street improvements that were largely or wholly local and private in character, from which the public has received very little and, in many cases, no benefit whatever. In support of this statement a single case may be instanced.

IMPROVEMENTS IN THE FENWAY DISTRICT.

A report upon this improvement, reciting the leading facts in the case, was made to your commission by Messrs. Metcalf & Eddy, Consulting Engineers, and was at my request submitted to me for my information. A group of six streets, Boylston, Jersey, Queensberry, Peterborough, Ipswich and Lansdowne, is embraced in the general scheme, though they were not all improved at the same time, and the history of some differs from that of others. It is intended here to consider results only, and reference is made to the report of Messrs. Metcalf & Eddy for the facts in detail.

Briefly, it appears that the owners of a large tract of marsh land in the Fens solicited the co-operation and aid of the city to improve the property so that they might put it on the market. Their proposition was that the city should carry out the improvements in accordance with plans approved by it, and with the understanding that the whole cost of the improvement should be assessed against the property and paid for by its owners.

The proposition that the whole cost should be assessed upon the property seems to have been a fair and equitable one, since it was undertaken almost wholly for the benefit of the owners of the property, and the public would not be greatly benefited thereby, and whatever benefit did accrue

to the public would be fully paid for by the administrative care and the incidental costs that the city would have to assume.

Essentially, the proposition was that the city should advance the money necessary, should make the improvements under the municipal machinery and should accept and legalize the improvements when completed.

The history of the transaction, as outlined in the report referred to, is interesting and instructive. Undertaken for the benefit of the private owners of the property, no sooner was the work under way than these parties began to antagonize and put the city on the defensive, and no effort was apparently spared to compel the city to pay a large part of the cost of the improvement.

These efforts were eminently successful. Six streets in all, with their sewers, were constructed. One of these streets extended outside the particular tract of land we have referred to, but was substantially a part of the improvement.

The city's account with the improvement is not yet closed, as some comparatively minor items are yet to be adjusted, but when closed the account will stand about as follows:

FENWAY IMPROVEMENT IN ACCOUNT WITH THE CITY OF BOSTON.

	Dr.	
To land damages paid by the city	$672,151 04	
To construction of highways	319,570 27	
To construction of sewers	255,468 39	
		$1,247,189 70
	Cr.	
By assessments levied on property	$509,163 66	
Less rebates	178,829 77	
Leaving valid assessments	$330,333 89	
By probable valid assessments on Lansdowne street	8,900 00	
		339,233 89
Balance due city		$907,955 81

Taking the actual cost and assuming that all the above valid assessments will be collected by the city, the net result will be that only about 37 per cent of the cost was actually (or effectively) assessed upon the owners of the property.

Of the assessments treated as valid in the above account there remains to be collected by the city nearly $84,400. Whether this will all reach the city treasury remains to be seen.

The total cost as shown by the city books is, as given above, $1,247,189.70, but certain items that enter into the actual cost to the city are not shown by the record. The city advanced the funds for the prosecution of the work, and provided these funds by the sale of bonds, upon which interest was paid. The amount of this interest is not shown in the report, and cannot be determined accurately, as it is complicated with questions of interest on deferred payments for land damages. Approximate computations indicate that it amounted to about $67,500. Adding this to the balance of $907,955.81 shown in the account above would make the net sum invested in the improvement by the city $975,456.

Furthermore, the city accounts do not show the cost of laying out the streets by the Street Commission, the cost of the litigation in which the city was involved on account of the improvement, the cost of the crushed stone used over the price at which it was charged up, and other miscellaneous expenses. These items are not shown on the books, and it would doubtless be difficult to obtain them. It is probably safe to say that they aggregated a sum sufficient to raise the above balance to at least $1,000,000, and we may, therefore, say that the actual net investment of the city in this improvement is about $1,000,000.

The annual interest on this sum at 4 per cent amounts to $40,000, and to this amount must be added the cost of maintaining the streets, which is small now, but may, in the future, amount to quite a considerable sum yearly.

Besides this, the city should have established a sinking fund to pay off the debt incurred. If we assume that the bonds run thirty years and that 3½ per cent can be realized

upon money in this sinking fund, the annual payment into it will amount to $19,370, which, added to the interest charge above, makes the annual cost to the city $59,370.

What does the city get in return for this large annual expenditure? It gets only the increased taxes due to the enhancement of the value of the property by the improvement.

In 1894, or about the time these improvements were begun, the whole tract was assessed for taxation at $2,150,800. In 1906, with the improvements practically completed, the same property was assessed at $3,718,500, an increase of $1,567,700. A part of this increase was doubtless due to the natural enhancement of values which occur in every growing city, and a part to the filling in of low grounds by the owners; but if we assume that the whole of it was due to the effect of the improvement of the streets, the increased taxes received from the property will amount in 1908, when the rate of taxation is $16.50 per thousand, to $25,867, leaving an annual deficit, to be charged by the city to the improvement, of $34,503. In order that the increased taxes may be sufficient to meet the annual expenses of $59,370 the property must reach a taxable value, at the present rate of taxation, of nearly $6,000,000.

It is not possible to say when, if ever, the property will attain this value, but in the meantime the accumulation of interest and sinking fund (less the taxes collected) will go on, and it may safely be predicted that it will be a long period before the city will come out even on the transaction.

It is true that no small part of the disastrous outcome was chargeable to the mismanagement of the improvements by the city and to its failure to comply with agreements and obligations entered into, but this does not affect the importance of the lesson taught — that a municipality should not lend its aid to the making of private improvements, depending upon special assessments for repayment of the cost, unless the payment of such assessments in full can be amply secured.

It would doubtless be found that while there have been few, and perhaps no other similar transactions of equal

magnitude, this one is fairly typical of hundreds of others, the aggregate losses on which to the city would be a very large sum.

Such cases can only be fitly characterized as the improvement of private property at public expense.

CONSTRUCTION AND MAINTENANCE ACCOUNTS.

In the accounts for street work it is important that the cost of *construction* should be kept separate from the cost of *maintenance*. It is sometimes difficult to distinguish between the two or to separate the one from the other. But if a set of principles or rules be framed and adopted, defining what is construction and what is maintenance, there will not be much trouble in keeping the accounts substantially correct. The importance of such a separation is recognized in most business and industrial enterprises, but is too frequently neglected in municipal public work. Charges for new construction are additions to the capital account, while maintenance can properly be charged to current expenses only. The necessity for the distinction would appear at once if it were attempted to make up a correct balance sheet of the assets and liabilities of the city, which every annual report ought to contain. But if the maintenance of pavements, for instance, be charged to capital account the aggregate charges to that item would greatly exceed the true value of the pavements, and a correct balance would be impossible.

For this reason the practice of creating a permanent indebtedness, that is, of issuing bonds for street maintenance, is unwise and wrong. All purely maintenance charges should be paid for out of the funds appropriated for that purpose. I believe that it is not customary in Boston to issue bonds to pay for street work that is *purely* maintenance. But this is often done in effect where a street is repaved, the old pavement being replaced by one of a more expensive kind. In such cases only the *betterment, i. e.*, the excess of the cost of the second pavement over that of the first should be paid for by bonds. Manifestly, if bonds are issued for the whole cost the result must be that the city's indebtedness is increased without any corresponding increase in its assets.

CONCLUSION.

As may readily be inferred from what I have said, my contention is that street paving, as a branch of municipal work, should receive the same careful scientific and technical consideration and treatment by municipal engineers as other public works and utilities. There can be no doubt that in the past it has been sadly neglected. Compare, for instance, the relative engineering attention given to water supply and to paving in our American cities. The one has been carefully studied, very complete data and statistics collected, and nearly all its principles and problems worked out, both from the scientific and the practical points of view. Conditions being given, and the results desired being decided upon, in any ordinary case, we have the data and formulas at hand to determine how the desired results can be attained most economically and satisfactorily. In short, the whole subject of city water supply engineering has been placed upon a scientific basis. In the other, the necessary data have not been collected, little attention has been given to applying scientific methods to the treatment of such data as we have, and the whole subject remains, to a very considerable extent, one of personal opinion or guesswork even among city engineers.

Considering the great importance of street pavements, from both the financial and the utilitarian point of view, this situation is inexcusable.

It cannot be too strongly urged that Boston as well as other American cities should set about the securing of a reform in the matter by collecting and recording the elemental facts which, when properly classified and condensed into systematic shape, will serve as a foundation for the same scientific and economic consideration as has long prevailed in other engineering departments of municipal work.

It was partly with this in view that I have recommended that the designing and construction of street pavements be placed under the exclusive control of the department of the City Engineer.

CHAPTER VI.

SIDEWALKS IN BOSTON.

While I have not been able to make a very thorough study of the matter of sidewalks in Boston, the subject seems to be of sufficient importance to warrant a brief statement and discussion.

LEGISLATIVE HISTORY.

For years previous to 1891 sidewalks on streets already built were constructed by order of "The Mayor and Aldermen or Selectmen or Road Commissioners," not more than one-half the cost being assessed against the abutting property owners, the balance being paid by the city out of the regular maintenance appropriation for the Street Department. No special appropriation for sidewalks was made by the city. It was found that only a limited amount of money could be spared from the regular street maintenance appropriation, and the result was that sidewalk construction was greatly retarded.

The Act of 1891 (chapter 323, Acts of 1891) authorized the building of sidewalks on new streets constructed by order of the Street Commissioners as a part of the general improvement, the whole cost of which was assessed against the abutting property owners, but this act did not change the status of sidewalk construction along old streets previously built. It applied to new streets only; that is, those coming under the jurisdiction of the Street Commissioners.

In June, 1892, an act was passed by the Legislature (chapter 401, Acts of 1892) which provided that the Mayor and Aldermen might direct the Superintendent of Streets to construct sidewalks along any of the streets of the city. The immediate cost of the work was to be paid out of the city funds, provided under chapter 323, Acts of 1891, but the whole of it was

eventually to be specially assessed by the superintendent of streets against the property abutting on the sidewalks pro rata to the number of feet of the abutting property of the several owners. As the city could appropriate a million dollars per year under this act abundant funds for the purpose were available.

Under this law the construction of sidewalks progressed rapidly. But the practice of charging the whole cost to the property owners was not popular, and in June, 1893, the Legislature passed another act (chapter 437, Acts 1893) which practically repealed the act of the previous year and provided that not more than one-half of the cost of any sidewalk might be assessed against the abutting property. It also provided that:

> When any such sidewalk shall be permanently constructed with edgestones and covered with brick, flat stones or concrete, as aforesaid, there shall be deducted from the assessment therefor any sum which shall have been previously assessed upon the abutting premises and paid to the city for the expense of the construction of the same in any other manner than with edgestones and with brick, flat stones or concrete, as aforesaid; and such deduction shall be made pro rata and in just proportions from the assessments upon different abutters who at the same time of such assessments are owners of the estate which at the time of such former assessments was the estate of the abutters who had previously paid such former assessments.

In other words, if there has been an earlier sidewalk of any kind other than brick, flat stones or concrete, any part of the cost of which had been assessed against the abutting property, the amount so assessed must be deducted from any proposed assessment for the new sidewalk.

It might, therefore, occur in the case of such rebuilt sidewalks that no part of the cost could be assessed against the abutting property. The act made no provision for appropriations to pay for sidewalk construction, and the annual report of the Street Department for 1893 stated that the practical effect of the law was to stop all sidewalk improvements. This does not, however, seem to have been the case, since the construction of sidewalks proceeded on a small scale thereafter, the city's portion of the cost being paid out of the general street maintenance appropriation.

A later law, chapter 82 of the Acts of 1894, further nullified the results of the Act of 1892 by providing that:

> The City of Boston may repay to the person paying the same, or to his legal representative, any portion not exceeding forty-five per cent. of any sums that have been or may hereafter be paid for assessments for the construction of sidewalks under the provisions of chapter four hundred and one of the acts of the year eighteen hundred and ninety-two.

The word "may" in this act seems to have been construed to mean "shall," and it appears that in every case where the whole cost had been assessed upon the property owners under the Act of 1892 the 45 per cent was repaid to the property owners. A loan of $100,000 was authorized December 31, 1895, to repay these assessments.

The Act of 1893 (chapter 437, Acts of 1893) remains in force, except as it was modified by chapter 393, Acts of 1906. Under this last named act the Street Commissioners are given entire control of public street improvements involving the laying out, relocating, altering, widening or discontinuing or of changing the grade of any highway or public alley, *including the construction or reconstruction of sidewalks along such highways*, and may direct the Superintendent of Streets to carry out such improvements. Under this law not more than one-half of the cost of an improvement may be assessed upon the abutting property owners, and in practice a much smaller part, often not exceeding 10 per cent of the whole cost, is so assessed. But this law applies to such streets only as thus come under the control of the Street Commissioners. Consequently the construction or reconstruction of sidewalks on all other streets must be carried on under the earlier acts and that of 1893, and in no case can more than one-half the cost of sidewalks be assessed against abutting property holders.

Under the laws as they now stand only one assessment can be made against property owners for the construction of sidewalks. In other words, when a sidewalk, of whatever character, has been once built and a part of its cost assessed against the property owners the city must forever thereafter maintain it wholly at the expense of the city. This extends to the rebuilding of the walk whenever it may become neces-

sary or desirable, even though a wider and much more expensive kind of walk shall be substituted for the original.

Under the law of 1891 (chapter 323) a petition of abutting property owners was required to initiate a sidewalk improvement. But the law of 1893 (chapter 437) conferred upon the Mayor and Board of Aldermen the right to initiate and carry out the construction of sidewalks, with or without edgestones, in any street of the city. But this right seems to be very seldom exercised, since nearly all sidewalk improvements originate with petitions from the property owners.

PRESENT PRACTICE.

The more extensive construction of sidewalks on streets already established by city initiative is not pushed because there is no special appropriation for building sidewalks, and the city's share of their cost must be paid out of the general appropriation for street maintenance, which is not sufficient, it is claimed, to meet the cost of a large quantity of sidewalk work. The fact that a part of the cost, not exceeding one-half, may be assessed against abutting property owners does not help the situation, since the sums so assessed do not return to the appropriation, but are paid into the city treasury in the same manner as taxes are paid. In other words, the whole cost of constructing sidewalks, in accordance with the present law, is actually taken out of the appropriation for street maintenance.

In practice this provision of the law is circumvented, so far as the assessable cost is concerned, by a custom outlined below, for which there seems to be no legislative authority, though it may not be illegal.

In the case of the standard brick sidewalk it is assumed, and is substantially true in average cases, that the cost is about equally divided between materials and labor. The city, therefore, instead of building the sidewalk wholly at its own expense, and then assessing half the cost against the abutting property, says, in effect, to the property owners, "If you will provide the materials at your own expense we will supply the labor and do the work." The result is that only one-half of the cost of building the walk is taken from the

street maintenance appropriation. This practice is defended upon the ground that, since the street maintenance appropriation is inadequate, if only half the cost of construction be taken from the appropriation, twice as much sidewalk work can be done as would otherwise be possible. It does not, of course, affect the city treasury at large, since if the whole cost of construction were incurred by the city and one-half of it subsequently collected by assessment upon the property owners, the final result would be the same.

The usual procedure in the case of standard brick sidewalks is as follows:

One or more property owners desiring to have a sidewalk built in front of their property fill out and present to the Board of Aldermen a petition on a general blank form provided for the purpose. This petition stipulates that the work is to be done in accordance with chapter 437, Acts of 1893.

If the petition is granted by the aldermen a suitable order is adopted. If the work is to be done under the prevailing method, where the property owner supplies the materials, a slightly different form of an order is used.

Upon the receipt of such an order the Superintendent of Streets proceeds to construct the sidewalk. If the work is to be done under chapter 437 he provides all the materials and labor, and when the walk is completed in accordance with the regular routine he assesses one-half the cost upon the property owner, to be collected and paid into the city treasury in the same manner as taxes.

If the property owner is to supply the materials, he authorizes the Superintendent of Streets, on a suitable blank form, to order the necessary edgestone from the penal institutions at his (the property owner's) expense and supplies the other materials required. When the edgestone is delivered and paid for by the property owner and the other materials are provided, the Superintendent of Streets proceeds to do the work with the department forces. When completed no assessment proceedings are necessary, since the property owner has already paid his half of the cost by supplying the materials, and the city's half of the cost has been expended from the street maintenance appropriation.

As both the cost of the materials and that of the labor may vary within quite wide limits on different sidewalks this practice may result in the payment of more or less than half the cost by the city.

In case, however, the property owners desire to have an artificial stone sidewalk, instead of the standard brick sidewalk, the proceedings are different.

Under the law artificial stone sidewalks stand upon the same footing as brick sidewalks; that is, they may be built under chapter 437, and one-half their cost assessed against the abutting property owners. A very few sidewalks are thus built. The great majority of them are built in accordance with a practice of the Street Department, which, while it may not be illegal, seems to have no authorization in law. Its object is to prevent the depletion of the street maintenance appropriation by sidewalk building. It is justified by the department upon the ground that it makes possible the construction of a much larger quantity of artificial stone sidewalk than would otherwise be possible by compelling the property owners to pay a larger part of the cost than the law provides. It is based upon the assumption that the department cannot afford to pay, where artificial stone sidewalks are wanted, more than one-half of what a standard brick sidewalk would cost. The department says, in effect, to the property owner, "If you want a more expensive sidewalk than the standard brick, we will authorize it upon the understanding that the city shall bear only one-half of what would be the cost of a brick sidewalk, you to bear all the balance of the cost." For the purpose of such an arrangement it is assumed that the average cost of a brick sidewalk is 12 cents per square foot, the city's share of which would be 6 cents per square foot, and the city, therefore, contributes only that sum per square foot toward the construction of the artificial stone sidewalk.

The methods by which these arrangements are carried into effect are briefly as follows:

The property owner petitions the Board of Aldermen for an artificial stone sidewalk, using a form provided for the purpose. If granted, an order is issued to the Superintendent of Streets to build the sidewalk.

If the work were to be done in compliance with chapter 437, the Superintendent of Streets would proceed to have the walk built by contract, and when the work was completed half its cost would be assessed against the property owner.

But where the work is to be done in accordance with the method established by the department (as it is in nearly all cases) the procedure is as follows: It is based upon the idea that since the property owner must pay the greater part of the cost he may select and make his own terms with any approved contractor, subject to the conditions that the work must be done in accordance with the city's standard specifications and under the direction of a city inspector.

To provide for such cases the city enters into contracts of a general form for the construction of artificial stone sidewalks with a number of approved contractors, agreeing to pay them at the rate of 6 cents per square foot for any such authorized sidewalks they may construct.

These contractors may solicit and enter into contracts with property owners for constructing artificial stone sidewalks.

When a property owner has made such a contract for an authorized sidewalk he notifies the Superintendent of Streets on a blank form provided for the purpose, and the work is carried out under the supervision of the city. When it is completed, and the necessary conditions complied with, the city pays 6 cents per square foot to the contractor, who collects the balance due from the property owner in accordance with the private contract between them.

The result is that the city pays, as its share of the cost, what it assumes would be half the cost of a brick sidewalk, and no assessment proceedings are necessary.

Crushed stone sidewalks are seldom constructed except upon new streets under the direction of the Street Commissioners, in connection with the general improvement of the street, and in compliance with the law governing such improvements.

COMMENTS ON PRESENT PRACTICE.

The peculiar methods outlined above, which evade to some extent the existing laws, are undoubtedly advantageous to the Street Department for the reasons stated above, and in some minor respects they are advantageous to the city. If it be true, as claimed, that the street maintenance appropriation is not sufficient to keep the streets in repair, and at the same time devote any considerable sum to sidewalk construction, then any just and legal device that will enable the department to greatly increase the quantity of sidewalk work that it would be possible to do in strict accordance with the law should be beneficial in a city distinctly deficient in the quantity and quality of its sidewalks. The elimination of the delays and uncertainties that always attend the laying and collection of special assessments must also be advantageous to the city.

On the other hand, these methods are open to the objection that they are not authorized by law. Whether they are legally permissible or not is a question for the lawyers. It is usually held by the courts, I believe, that municipal officers can only expend the corporation funds in accordance with the terms prescribed by law, and it is a question whether the expenditure of money in however good faith and for whatever legitimate purpose, through methods other than those prescribed by law, is a prudent and safe course for a city department to follow.

The contracts entered into by the Street Department with various contractors for the construction of artificial stone pavements, while upon printed forms, are in some respects open to criticism, and are possibly illegal in some particulars, but as the city's liability under them is comparatively small the matter is not very important.

The practice now in vogue seems to recognize brick sidewalk as the official standard sidewalk of the city. Where property owners petition for the construction of some more expensive kind, as artificial stone, the Street Department usually grants the petition upon the express condition that the city will pay only what is estimated to be one-half the

cost of the standard brick sidewalk. When, therefore, property owners prefer a better kind of walk the city agrees to pay, as its share of the cost, one-half of what a brick walk would cost, only, and the property owners must pay the balance. The effect of this is to discourage the use of any but brick sidewalks. This is unfortunate from every point of view and will be referred to later. The incentive to petition for a cheap though inferior sidewalk is greatly increased because of the fact that when such a walk has once been constructed and a part of its cost assessed upon the property owner, he is forever relieved of any further expense for its maintenance or for its reconstruction with a superior and more costly material.

It has been and still seems to be the practice in Boston to consider the edgestones as a part of the sidewalk rather than as a part of the roadway, and to assess upon the property owners a portion of the cost of the edgestone in connection with the sidewalk improvement. Not only this, but the practice has been extended further, and edgestones have been provided and set under the provisions of the sidewalk laws where no sidewalks have been constructed, and a part of its cost assessed against the abutting property owners.

Chapter 437, Acts of 1893, reads in part as follows:

> SECTION 1. The mayor and board of aldermen of the City of Boston may grade and construct sidewalks, and complete any partially constructed sidewalk in any street of such city, as the public convenience may require, with or without edgestones, as said board shall deem expedient, and may cover the same with brick, flat stones, concrete, gravel or other appropriate material, and may assess upon the abutters on such sidewalks in just proportions, not exceeding one-half of the expense of the same.

This seems to imply that while edgestones may be set in connection with the construction of a sidewalk, they are not authorized where no sidewalk is built. If so, assessments upon property owners for the construction of edgestone where no sidewalk is built in connection therewith may be illegal, and the courts might decide that they are void and recoverable by the persons so assessed. This is a matter worth looking into by your legal advisers.

However, this may be, the edgestone is essentially a part

of the roadway rather than of the sidewalk, except, possibly, in the few instances where the edgestone and the sidewalk are constructed of concrete as a single, monolithic structure. Curbing or edgestone is nearly always, in other cities, constructed, maintained and reconstructed at the same time and as a part of the roadway. This is logical and proper, since the edgestone is really a part of the structure of the roadway, having usually no physical connection with the sidewalk. The distinction would be of practical importance if, as herein recommended, the law should be so amended that the entire cost of the *sidewalk* may be assessed against abutting property, while the law relating to the pavement of the *roadway* might remain as it is now.

I know no other large city where the curbing is treated as a part of or belonging to the sidewalk.

CITY INITIATIVE IN BUILDING SIDEWALKS.

Sidewalks are seldom built in Boston except where petitioned for by property owners. The reason for this has already been explained. However sound this reason may be from the financial standpoint, the result is most unfortunate for the city. Good sidewalks are as essential as well paved roadways, and they probably contribute even more to the comfort of the public and to the good appearance of the city. Their construction should not only be encouraged but *enforced* by the city. Careless or penurious property owners who lack the public spirit to properly improve their property in this respect should be forced to do so.

Excepting the business districts, it may be asserted without fear of contradiction that no large city in the country is so far behind the times in the matter of sidewalks as Boston. Not only are they entirely absent on many stretches of street where they should have been constructed long ago, but a large proportion of those existing are of inferior kind and quality. Where the matter is left largely to the property owners vacant stretches and walks of different kinds, widths and quality may be found alternating on the same street and often on the same block. Perhaps no one thing detracts more from the good appearance and attractiveness of a

residence block than such a condition of affairs. The city should, not only for its own benefit and credit, but for the good of its citizens, exercise complete control over the design and construction of sidewalks.

APPROPRIATIONS.

The absence of separate appropriations for sidewalk purposes seems to be most largely to blame for the present unsatisfactory system of dealing with sidewalks in Boston. They are treated as the residuary legatee of the street maintenance appropriation, and as this appropriation is asserted to be inadequate for the roadways alone, the sidewalks seem not to have a fair show. The building of new sidewalks must depend largely upon the voluntary action of property owners, and the proportionate help these property owners receive from the city is determined by the cheapness and inferiority of the walk they select. They are, in effect, penalized for showing sufficient good judgment and public spirit to choose a high-class sidewalk.

The present system of handling the sidewalk matter ought to be wholly changed, but if it is to be continued then a separate appropriation should be made for the construction and maintenance of the sidewalks of the city, so that the sum to be devoted to them may be definitely determined and not left to the judgment of the Street Department or be dependent upon what that department thinks it can spare for the purpose.

CONTRACTS FOR SIDEWALK WORK.

It appears that more than half of the actual work of constructing sidewalks is now done by the city forces. While the artificial stone sidewalks are laid by contract the methods followed are open to serious criticism.

There seems to be no valid reason why all sidewalk work should not be done by contract, as I have recommended in the case of other street work. While the present cost of the work done by city forces cannot be ascertained, there is every reason, judging from what we have found in the case of

other street work, to believe that it is excessive, and that if done by contract it would result in a very considerable saving to the city.

While the contract prices for laying artificial stone sidewalks, as far as they are known, do not seem excessive, provided the work is properly done, they would doubtless be materially lower if the work were properly systematized and managed.

Where separate contracts are made for this work they cover small areas of walk, and as they are awarded at different times the contractors can never know what quantity of work they will have to do in any season. If the whole quantity to be done in the city in any one season could be mapped out, bids asked for doing it, and the contracts awarded early in the season, each successful contractor would know what quantity he must prepare to do, and would plan to begin and carry it on continuously until it should be completed. Obviously, he could do the work cheaper in this way than in disconnected jobs at various times with intervals between when he must disband his forces. Under the present practice, in the case of that class of work where the contractor must not only make a contract with the city, but must solicit his work from and make individual agreements with each property owner, besides doing the work in small disconnected jobs, the cost to him must be materially increased and he must demand higher prices than he otherwise would. The prices paid by the property owners, in addition to the 6 cents per square foot paid by the city, are not known, or at least they are not a matter of public record. They may be exorbitant, and doubtless are not uniform. If, as suggested, the work could be contracted for in large quantities under competitive bidding it would, without doubt, cost the property owner less than it does now.

Even if the property owner be compelled to pay the whole or the greater part of the cost of the work, it is due him that the city should make the burden as light as possible.

Many cities follow the plan here outlined of determining at the beginning of the season the quantities and location of the sidewalk work to be done, and then advertising for pro-

posals and awarding the various lots to the lowest bidders, embracing those awarded to each contractor in a single contract.

Such a plan could hardly be applied to the present heterogeneous system of sidewalk work in Boston, but that system should be reformed and consolidated so as to make it possible.

WHO SHOULD PAY FOR SIDEWALKS.

Sidewalks outside of the business districts are, in all except a few cases, purely local improvements for the benefit of the property owners. Their cost should, therefore, be specially assessed against the abutting property benefited. Not only is this true theoretically, but it is, in practice, the simplest and most equitable way of applying taxation to the purpose. Sidewalks are, or should be, universal along improved streets, and whatever method of paying for them is adopted nearly every taxpayer must, in the end, pay his proportionate share of their cost. If properly designed, their cost usually bears a fairly uniform ratio to the value of the abutting property. That is to say, the narrower and cheaper class of sidewalks are appropriately constructed in front of the less valuable residence property, while the wide and expensive walks are needed along the streets where residence or business property has a high market value. It may, therefore, be safely asserted that in no class of municipal work can the cost be specially assessed upon abutting property with such uniformly equitable results. So generally is this recognized that in the great majority of American cities sidewalks are wholly paid for by special assessment. There seems to be no sound reason why Boston should not do the same.

While the burden of paying for the sidewalks by abutting property owners is not usually heavy, it is possible and practicable for a city to make that burden very light by extending the municipal credit, so that the property owners may have a number of years in which to pay their assessments, as is now provided for in the case of street improvements ordered by the Street Commissioners, under chapter 393, of the Acts of 1906, permitting assessments to be paid in ten annual installments. But if this be done the provisions of the law should

be such that the whole of the cost, both principal and interest, incurred by the city shall be refunded by the person assessed.

CONTROL OF SIDEWALKS.

The city should reserve and assume complete control of the construction and maintenance of sidewalks. It should determine not only where and when sidewalks shall be laid, but the kind to be used, the width for different streets and the specifications under which the work shall be done. Petitions from property owners relating to these matters should be given due consideration, but should not be controlling. A general scheme for the sidewalk system of the city should be worked out, adopted and generally adhered to in all future work.

COST OF MAINTENANCE AND RECONSTRUCTION.

Ordinary maintenance and repairs should be superintended and paid for by the city for the reason, principally, that it is impracticable to satisfactorily arrange for the assessment of maintenance charges upon the property owners. Nor is it practicable to compel the property owners each to repair his own walk, for the reason that not only would such individual repairs be unduly expensive, but uniform character and quality of repair work could not very well be enforced. Repairs necessitated by injuries due to abuse or improper use of the walk by the property owner or others should be excepted and the cost collected from the person responsible. Such provision now exists. (See chapter 6, Revised Ordinances of 1898.)

When reconstruction becomes necessary as the result of ordinary wear and tear (to be determined by the city), the whole cost of reconstruction should be assessed upon the property owner in the same manner as if it were a new sidewalk. The same reasons which made it right and proper to so assess the cost of the original walk apply to its reconstruction.

The present laws, which throw the burden of both maintenance and reconstruction upon the city, are unreasonable and inequitable, if it be admitted that the property owners

should share any financial responsibility whatever in the matter. Where, for instance, the original walk is of crushed stone, costing very little, and one-half that cost is paid by the property owner, he is not liable for further assessment, even if it becomes necessary or advisable later to reconstruct it with expensive artificial stone. In such cases, even where the general principle that the property owner shall pay but half the cost of sidewalks is adopted, the law should permit half the cost of the *betterment* to be assessed upon the property.

Any law or practice which offers a strong inducement to the property owner to favor or petition for the poorest and cheapest kind of original construction is obviously disadvantageous to the interests of the city.

AMOUNT AND CHARACTER OF SIDEWALK WORK IN BOSTON.

There appears to be no record of either the length or the area of the sidewalks in Boston. Nor is it possible to find from the records or the annual reports of the Street Department the exact quantity constructed in any one year. Old sidewalks rebuilt by city labor appear not to be always recorded or reported. Exclusive of such, the area of sidewalk of various kinds built in the last three years appears to have been as follows:

YEAR.	Brick. Square Yards.	Artificial Stone. Square Yards.	Coal Tar. Square Yards.	Crushed Stone. Square Yards.	Total, Square Yards.
1905	58,800	13,700	3,551	—	76,051
1906	108,500	24,789	3,716	4,412	141,417
1907	56,213	23,496	2,409	21,868	103.986
Total, three years	223,513	61,985	9,676	26,280	321,454

At the prices which seem to prevail in Boston the cost of the sidewalk work done in 1907 may be roughly estimated as follows:

56,213 square yards brick sidewalk, at $1.08	$60,710 04
23,496 square yards artificial stone, at $1.85	43,467 60
21,868 square yards crushed stone, at $0.55	12,027 40
Total	$116,205 04

Roughly speaking, the city seems to have paid toward the construction of the brick and artificial stone sidewalks about $45,000. It is difficult to even approximate the cost to the city of the crushed stone sidewalks. They are largely constructed under chapter 393, Acts of 1891, and the acts amendatory thereto, in connection with street improvements, and some part of the cost was assessed against abutting property. The average percentage of the whole cost thus assessed is very small, so that the city has not only paid a large part of the cost of these cheap and inferior walks, but, under the present laws, is estopped from assessing upon the property any part of the cost of better walks when they become necessary.

From the above table it appears that notwithstanding the official favor shown to brick the use of artificial stone sidewalks is rapidly increasing. In 1905 the ratio of brick to artificial stone was over 4 to 1, while in 1907 it was less than 2½ to 1. This indicates sound judgment and healthy public spirit among those who petition for new sidewalks.

It appears from the above tabular statement that four kinds of sidewalks are now recognized and constructed in Boston, and the relative merits and cost of these may be briefly considered.

BRICK SIDEWALKS.

The sidewalk that the city now seems to recognize as the standard, while largely used in other cities, is really a very inferior one. It consists of brick laid flatwise on a foundation of six inches of gravel and sand (four inches gravel covered with two inches of sand), the joints between the brick being filled with sand. No provision seems to be made for drainage other than this six inches of gravel and sand. As the frost must penetrate to a greater depth than eight inches below the surface the walk may be, and doubtless often is, on wet and clayey soils, heaved up and distorted by the freezing. On such soils soft tile drains should be provided, as recommended later for artificial stone sidewalks. Where the edge of the walk does not rest against a wall or the edgestone it is held in place by spruce planks, which in turn are

supported by stakes of the same wood. These wooden supports must decay in a few years, allowing the bricks to spread and work out of place. The whole construction is faulty and the walk cannot be very durable. Even at its best, such a walk is unsatisfactory and unsightly. It is not such a sidewalk as any property owner of good judgment and taste would want in front of his property.

It is true that brick has some advantages for sidewalks. It is not so liable to be slippery in frosty weather as artificial stone, and snow and ice melt from it more quickly. But if brick is used it should be carefully selected and the walk properly constructed.

Where brick walks are laid by contract the city usually supplies the brick and the contractor furnishes all other material and does the work. Owing to the varying conditions, which are not apparent from the records, it is not possible to determine what has been the average cost of the work. It has probably not been below $1.10 per square yard. No guaranty of the work is exacted from the contractor. No figures are available as to the average life of such sidewalks, nor of the cost of maintaining them. They must be comparatively short-lived and the cost of keeping them in repair must be considerable. The low first-cost of this sidewalk is its only merit.

If a brick sidewalk is preferred it should be built in a more substantial manner. If gravel and sand only are used for the foundation the brick should be set on edge and the joints filled with Portland cement grout. But a better and really more economical construction would be as follows:

Over the six-inch drainage course should be laid a foundation course of two and a half inches of concrete, of the same quality as that used for artificial stone sidewalks. Upon this the bricks should be laid flatwise in a half-inch bed of Portland cement mortar, and the joints between the brick should be filled with Portland cement grout. Temporary edge plank or forms could be used and moved as the work progressed, since the brick thus laid would not need lateral support after the concrete and mortar had set.

A sidewalk thus constructed would probably cost at present

prices of material and labor from $1.50 to $1.55 per square yard, but its much greater durability and lower cost of maintenance would make it more economical in the end than the shabby brick walks now used.

ARTIFICIAL STONE SIDEWALKS.

Everything considered, a concrete (artificial stone) sidewalk, if properly built, is superior to any other yet devised. The growing preference for it by both city governments and the better class of property owners is the best evidence of its superiority.

The Boston specifications require that artificial stone sidewalks shall have a broken stone, screened gravel or soft-coal cinder foundation, or drainage course, twelve inches deep. Upon this is laid a course of ordinary concrete three inches deep and upon this again is laid the surface course, one inch deep.

The specifications for the work are not as full and definite as they should be and the construction adopted is open to criticism in a number of particulars.

The requirements that the foundation be carried to a depth of sixteen inches below the designed surface of the walk is unnecessary. Six inches of drainage course is sufficient. If the soil is wet and clayey, so that there is danger of heaving by frost, it is better and cheaper to lay a soft-tile drain under the walk than to put in twelve inches of cinders. In any event the drainage should be connected with the sewer or drain inlets. If this is not done the trench is likely to retain water, in which condition the walk is liable to be heaved by frost, however deep the drainage course may be.

If cinders are used for this drainage course they should be screened to remove the ashes and fine material, and they should be drenched with water several days before they are used. Otherwise, they are liable to slack and settle more or less under the concrete course. The three-inch concrete course, constructed according to the present specifications, is satisfactory, but its top surface should be carefully graded and tested with a gauge, so that the surface course shall everywhere have a uniform thickness of one inch. It is very

important that the surface course shall be applied and rammed before the foundation concrete begins to set. The surface course as now specified (composed of equal parts of cement and screenings or sand) may be, without diminishing its durability, materially cheapened by using a mixture composed as follows:

1½ parts of trap rock screenings or pea gravel.
1 part sand.
1 part Portland cement.

The screenings or gravel should be of such size that all will pass a ½-inch screen and all fine material that will pass a ⅛-inch screen should be screened out and rejected. The sand should be rather coarse—preferably, it should all pass a No. 10 sieve, and should all be retained on a No. 30 sieve. The cement for this surface course should be of the best quality and should all be tested before using, and the mixing and placing of this surface course should be thoroughly and skilfully done. In fact, the whole construction should be performed with care, since the success of artificial stone sidewalk depends largely on the good quality of the materials used and the care and skill with which the work is done.

For many residence streets where the width of the walk does not exceed 4½ feet the thickness of the surface course may be reduced to ½-inch and that of the foundation course to 3 inches, if the work be perfectly done, and the cost thus materially reduced. The two classes may be designated as No. 1 and No. 2.

At the present prices of materials and labor in Boston the No. 1 walk, constructed in the best manner, should be built complete for about $1.55 to $1.60 per square yard and the No. 2 walk for about $1.20 to $1.25 per square yard. These prices do not include the cost of the soft-tile drain, when this is necessary, which in a walk 4½ feet wide would add about four or five cents per square yard to the above prices.

The objection is sometimes made that the color of these artificial stone sidewalks is too white and glaring. This may be remedied by adding a little coloring matter to the cement. Thus one-half pound of lamp black added to 100 pounds of

the cement will make a dark gray surface, and six to ten pounds of yellow ochre will make a surface of buff color. The additional cost with this artificial coloring should not exceed a few cents per square yard of walk.

The contract prices for artificial stone sidewalk, as now constructed in Boston, seem to average about $1.80 per square yard and the contractor is required to guarantee his work for ten years. If the work be properly done this price is reasonable.

CRUSHED STONE SIDEWALKS.

It appears that nearly 22,000 square yards of crushed stone sidewalks were laid in 1907 at an average cost, apparently, of about 55 cents per square yard. Presumably this was largely used in sparsely settled parts of the city, where it was considered that a better sidewalk was not called for or warranted by the conditions.

While such sidewalks are a little better than none in wet and muddy weather, they scarcely deserve the name of sidewalk on an improved city street. The only valid excuse for constructing them is that they may possibly be utilized later as a drainage course for a real sidewalk. If a sidewalk is needed and justified at all on a city street something better and more permanent should be built at first.

A No. 2 artificial stone sidewalk, as described above, 4 feet wide, if assessed against the owner of a 50-foot lot would cost him less than $30. It would be a permanent improvement and would doubtless enhance the value of the property more than its cost. It would be better to postpone the building of any sidewalk until one of some permanence and value could be provided.

Crushed stone sidewalks are appropriate only in parks and country roads, and their construction along city streets should be discontinued.

COAL TAR CONCRETE SIDEWALKS.

Very little sidewalk of this kind seems now to be built in the city. It has doubtless been found that a really good walk of this kind costs as much or more than artificial stone, and that those built for a low price are too inferior to be tolerated.

Bituminous sidewalks, whether of coal tar or asphalt, have one advantage — snow melts from them more rapidly than from any other, but the greater cost of really good work of this kind makes them usually inadvisable.

BOSTON SIDEWALK SPECIFICATIONS.

What I said about the present street paving specifications in Boston applies as well to the specifications for sidewalks. They are incomplete and inadequate and should be thoroughly revised.

RECOMMENDATIONS.

In accordance with the considerations and conclusions preceding I respectfully recommend:

1. That the present laws be so amended as to authorize and direct that the cost of building and rebuilding sidewalks shall be wholly assessed upon the abutting property benefited.

2. That a general scheme, with appropriate rules and regulations, for the sidewalk system of the city be worked out and adopted. This should embrace the kinds and qualities of sidewalk permissible, the widths to be used on different classes of streets, their location with reference to the building and the edgestone lines, the radius of corners for streets of different width, etc. The object of such a general plan is to secure uniformity of practice, so far as it may be practicable, throughout the city.

3. That artificial stone be adopted as the standard material for sidewalks except where there may be special reasons for using some other kind. That if the use of brick sidewalks be for any reason continued they should be constructed of a better quality than the present specifications call for. That the use of broken stone for the surface of street sidewalks be discontinued.

4. That as far as may be practicable all sidewalk work be done by contract, after competitive bidding, and that so far as possible the work to be done in one season should be anticipated and planned out, and the whole placed under contract at the beginning of the season.

5. That edgestone be classed with and paid for as a part of the roadway rather than as a part of the sidewalk.

6. That the present specifications for sidewalk work be thoroughly revised and made to conform to the best modern practice.

It will doubtless be objected that the changes here recommended are too radical, and particularly that it will be impossible to secure a permanent change in the law which will permit the special assessment upon the property owners of the whole cost of sidewalks. If that be true, then it will be desirable to secure such modifications of the present law and practice as may be possible and practicable. Among these should be the following:

1. To divorce sidewalks from roadways, so that the former may be dealt with in practice as separate improvements. This should apply particularly to the work done under chapter 393, Acts of 1906 — street improvements ordered by the street commissioners. Permanent sidewalks could then be built along these new streets when needed, under chapter 437, Acts of 1893, and half the cost assessed upon the property owners; whereas now unsatisfactory crushed stone sidewalks are built, and, as we have seen, but a small part of the cost paid by the property owners.

2. To make a separate annual appropriation for sidewalks distinct from the general street maintenance appropriation. This would remove the present alleged reason for withholding funds needed for necessary sidewalk construction and maintenance and would also remove the necessity for the present questionable practices referred to earlier in this report. This appropriation should be large enough to meet the whole cost of contemplated sidewalk work for the year, but one-half of it would be returned to the city treasury by the collection of assessments on the property owners.

3. To encourage and promote the construction of higher class sidewalks by the city paying one-half the cost of these as well as of the inferior walks.

4. To construct all sidewalks under chapter 437, Acts of 1893, strictly in compliance with its provisions, and to assess the full half cost of the work upon the property owners. A liberal separate appropriation for sidewalks would make it possible and practicable to do this.

5. To construct and reconstruct all sidewalks under contracts awarded to the lowest responsible bidder, ascertained by public competitive bidding.

6. To ascertain and, as nearly as possible, determine at the beginning of the season the sidewalk work to be done during that season, and to place the whole under contract at a single letting as early in the season as practicable.

All this can be done without any change in the present laws.

If even these substitute recommendations could be carried out I feel that they would result not only in improving the present sidewalk conditions in Boston, but in a large saving of money to the city.

CHAPTER VII.

STREET CLEANING AND THE WORK OF THE STREET CLEANING AND WATERING DEPARTMENT.

Owing to the unsatisfactory form in which the accounts are kept it is very difficult, and in some cases impossible, to obtain the necessary data for an intelligent study and analysis of the business of the Street Cleaning and Watering Department. The system of accounting used was found to be as faulty as that in the Paving Division, which I have referred to previously, and it has been almost impossible within the time and means at our disposal satisfactorily to ascertain from the books the correct cost of details of the work.

The present system of bookkeeping is designed to show how the appropriations are expended and to classify the expenditures under a number of general heads rather than to determine unit costs of the work. But these unit costs are necessary in order to judge of the economy of the work. A great deal of effort was devoted to an attempt to get at such correct unit costs with but indifferent success.

In a few cases the figures published in the annual reports were found not to agree with the records of the office, being clerical errors, and they have been corrected. In some cases the distribution of quantities and costs are erroneous or misleading, and corrections have been introduced in the tables that follow later.

Under all of these conditions it is proper to say that, while the figures used and the deductions made therefrom are based upon and seem to be fully warranted by the records, accounts and reports of the department as we found them, they may not be strictly accurate, though they are believed to be so in the main.

The correct areas of the streets cleaned in any one district

or in the whole city are not known by the department. The areas in each district were determined in 1891, but the boundaries of the districts have been changed in the meantime. The department reckons by length rather than by area of streets, and the lengths used for the districts are in some cases incorrect. Thus, Federal street, a part of which was abandoned and is now occupied by the South Station, is still counted in the length of streets cleaned. Nothing short of a complete revision and recalculation of the street areas in the several divisions would give us a correct measure of the areas now cleaned. The department records of miles of streets give little clue to the areas, as the streets vary widely in width and one mile might easily involve double the area of cleaning of another.

Furthermore, while the paved streets are swept over their whole surface, only the gutters of macadam streets are usually swept, though on macadam streets having paved car tracks the tracks are also swept and the street counted as paved streets. Of course no accurate deductions of unit costs can be made unless the true areas cleaned are known.

The general scheme of organization of the Street Cleaning Department and Watering Division appears to be well devised and satisfactory.

The general statistics of the Street Cleaning Department for the years 1900 to 1907, inclusive, as collected from the books and reports, are given in Table No. 33. It gives the accounts as they are kept and reported by the department.

It will be observed that a number of the items have varied but little in the eight years. Thus, the cost of superintendence has remained nearly the same during the period, the apparent increase in the item for 1906 being largely due to the fact that a part of the purchase price of two automobiles was, for some reason, charged to this account.

The length of street (miles) machine swept has increased only about 1 per cent, and the cost of sweeping per mile has remained substantially the same. The miles of gutter cleaned has increased about 21 per cent, but the cost of cleaning these gutters per mile of street has decreased from $7.72 to $5.98, or about 22 per cent. The cost of maintain-

ing dumps has increased 28 per cent, though the number of loads of dirt sent to the dumps has increased less than 7 per cent. The cost of removing snow and ice by the regular force has increased from $10,054 to $7,895, but this may only signify that much more work of this kind has been done in the later years. The cost of patrolling by districts (paper patrol) outside the push-cart patrol system has increased about 28 per cent, while the quantity of trash collected by it has increased 52 per cent and the cost per load of trash collected has decreased from $1.33 to $1.12. It is possible that the quantity of paper and rubbish thrown on the streets has increased, thus making it easier and cheaper to collect a load of it.

In all the above there is nothing to attract special attention. The fact that the figures have remained fairly constant, or show only a normal increase during the period of eight years through a number of administrations, indicates with regard to these particular parts of the work that the management of the department has been quite uniform.

This is not true, however, of a number of the other accounts.

Thus, the charge for miscellaneous work has grown from $911 in 1900 to $8,633 in 1907, and in 1905, $12,728 was charged to this account.

The cost of the push-cart patrol system has increased about 55 per cent, while the number of loads of dirt collected by it has decreased 11 per cent, and the cost per load of dirt collected has almost doubled.

The stable and yard account has increased more than 100 per cent, though the number of horses kept has increased only 26 per cent.

Miscellaneous expenses have increased 68 per cent. This item includes, however, a large part of the holiday pay allowed, which has been increasing rapidly in recent years, and over which the department has not full control.

These accounts, which seem to show abnormal increases in cost, will be considered more in detail further on in this report.

The total expenses of the department have been, for the eight years, as follows:

1900	$339,747	1904	$434,173
1901	356,445	1905	448,838
1902	392,802	1906	465,006
1903	403,626	1907	501,689

This shows an increase of nearly 48 per cent in the eight years.

When it is remembered that the miles of paved streets and gutters cleaned by machine has increased but about 5 per cent, and that while the area cleaned by the patrol may have been materially increased, the total loads of dirt collected by the department has increased less than 7 per cent, so great an increase in the total cost of administering the department excites surprise and justifies inquiry into the cause.

The number of men employed by the department has increased from about 360 in the latter part of 1900 to nearly 500 in 1907, an increase of about 39 per cent in the eight years. The rate of increase has not, however, been regular during the period. There appears to have been an abnormal increase in the force in the first half of 1901, and a diagram of the average monthly force shows great fluctuations during each one of the years, exclusive of the sudden temporary increases in the employment of emergency forces to remove snow.

The total increase in the expenses of the department from 1900 to 1907 was $161,942. The bulk of this is made up of increases in a few items, as follows:

Removing ice and snow	$64,841
Miscellaneous work	7,722
Miscellaneous expenses	15,408
Push-cart patrol	30,221
Stables and yards	41,314
Total	$159,506

These accounts may be considered more in detail.

SNOW REMOVAL.

Table No. 34 contains all the information obtainable from the records in regard to the cost of snow removal.

Table No. 34. — Street Cleaning Division.

Statistics of Snow Removal for Eight Years.

YEAR.	SNOW REMOVED BY ALL FORCES EXCEPT DISTRICT 11 PATROL.			SNOW REMOVED BY DISTRICT 11 PATROL.			Total Cost.	Total Loads Removed.	Cost per Load.
	Cost.	Number of Loads Removed.	Cost per Load.	Cost.	Number of Loads Removed.	Cost per Load.			
1900.....	$11,212	14,804	$0 758	$1,816	354	$5 13	$13,028	15,158	$0 860
1901.....	29,803	40,881	730	4,518	1,493	3 03	34,321	42,374	811
1902.....	38,091	45,335	840	5,244	1,113	4 72	43,335	46,448	933
1903.....	31,375	49,259	637	6,137	1,044	5 88	37,512	50,303	746
1904.....	51,512	69,748	738	10,169	2,049	4 96	61,681	71,797	860
1905.....	50,667	55,884	908	6,770	1,399	4 84	57,437	57,283	1 004
1906.....	38,653	39,460	980	8,687	1,719	5 06	47,340	41,179	1 150
1907.....	60,736	59,572	1 020	14,160	8,179	1 73	74,896	67,751	1 105
Totals..	$312,049	374,943	—	$57,501	17,350	—	369,550	392,293	—
Averages.	—	—	$0 834	—	—	$3 31	—	—	$0 942

The work of snow removal has been done partly by the regular street cleaning force and partly by the push-cart patrol, each employing emergency forces when necessary. The table shows that the number of loads of snow removed by both forces in 1900 was 15,158 and the total cost was $13,028, the cost per load being 86 cents. The number of loads removed in 1907 was 67,751, the total cost $74,896, and the cost per load was $1.10½. The increasing quantity removed was doubtless determined by the demands of the public. The increased cost per load removed is partly due to the higher wages which the department was compelled to pay for men and teams in the last year; but this alone will not account for the whole increase of 38 per cent in the cost per load. It is impossible to obtain reliable details from the records that will throw light upon the causes of this increased cost. Snow removal is usually, in all cities, emergency work, extending over a short time and involving a sudden increase in the number of employees of the Street Cleaning Depart-

ment, without the organization necessary to perfectly control and keep track of the expenditures. The cost is determined by local conditions in each city, and comparisons of cost in different cities are therefore not of much value. But it may be of interest to note that the comparative cost of removing snow per cubic yard in the winter of 1906–07 in Boston and in New York, assuming that a load in Boston equals two cubic yards, was as follows:

Boston	$0 55
New York, Manhattan and the Bronx	16½
New York, Brooklyn	21½

There is no known reason for so great a difference of cost in the two cities, unless it be found in the fact that in New York the work is done by contract instead of by the city forces direct, as in Boston.

There appears to be a wide and unaccountable difference in the cost of snow removed by the regular force and by the patrol sweeping force. The former shows a gradual increase in cost per load from 76 cents in 1900 to $1.02 in 1907. The figures for the latter, as shown in Table No. 34, are anomalous.

There is obviously something wrong here, but no explanation is obtainable from the department. The sudden drop in the prevailing cost per load, from about $5 in the previous years to $1.73 in 1907, cannot be analyzed from the accounts. It is possible that the work of the patrol force was partly confined to the cleaning of crossings, the snow from which was not at once hauled away, and therefore not credited as "removed."

The most practical remedy for what seems to be great extravagance in this part of the department work is to provide for the removal of snow by contract, as is now done in New York.

If the snow could have been removed in 1907 by contract at 25 cents per yard (and it is probable that a lower price could have been secured) the city would have saved about $65,000 on that item alone.

MISCELLANEOUS WORK.

It is impossible to ascertain from the records exactly what is covered by the item, in the 1907 report, of $8,633 charged to "Miscellaneous Work." Some expense of that character was doubtless necessary and legitimate, but it is difficult to understand how so large a sum could have thus been expended; and particularly why, while the work accomplished by the department has not greatly increased in eight years, this item of expense should have grown from $911 to $8,633 in the same period. It will be noted that in 1905, $12,728 was charged to this account. From the fact that more explicit records are not kept of the items of this account, the suspicion seems warranted that it may not bear careful investigation. This charge for miscellaneous work should be rigidly investigated by the head of the department.

MISCELLANEOUS EXPENSES.

This large account in the expenses of the department is made up mainly of allowance for holiday pay, all of which, except that for the push-cart patrol force in Districts 10 and 11, is charged into this account. In addition to holiday pay the account contains the sum paid to the Sanitary Department for towing street sweepings to sea, a comparatively small charge to sundries and a charge for an annuity decreed by the courts. The amount paid for towing sweepings to sea has increased with the quantity of material thus disposed of, and the holiday pay has increased with the total pay roll.

It appears that the rate or percentage of holiday pay for the whole force has not increased very materially, as shown by Table No. 35, which shows the total pay roll account and total holiday account of the department. The pay roll account includes the pay of the salaried officers and employees whose holiday time is not charged to holiday pay. The percentages in the last column are therefore slightly smaller than they should be, but it appears that the holiday pay has not been excessive.

Upon the whole, the increase in this account for miscellaneous expenses appears to be legitimate and reasonable.

Table No. 35.—Street Cleaning Division.

Labor and Holiday Charges.

YEAR.	Average Weekly Number of Men.	Total Pay Roll, Year.	Total Charged to Holidays.	Per Cent Holidays of Pay Roll.
1900	356	$238,610	$14,156	5.94
1901	383	253,686	20,266	8.00
1902	431	279,631	24,905	8.91
1903	423	293,306	26,878	9.16
1904	450	309,760	27,379	8.84
1905	475	319,052	26,762	8.39
1906	491	316,989	26,272	8.29
1907	485	355,491	31,773	8.94

PUSH-CART PATROL SYSTEM.

The work of this force is confined to the hand-sweeping of certain sections of the city and the disposal of the street dirt thus collected. The larger part of this work is in District 11 (comprising parts of Districts 8 uptown, 8 downtown, and District 9); the greater part of the balance is in District 10, with small amounts in Districts 1, 2, 3 and 7.

The accounts for this push-cart patrol work are kept entirely separate from the other accounts of the department. It does not include the account "Patrolling by Districts" (commonly called paper patrol) as given in the annual reports, which relates entirely to the collection of the paper and rubbish deposited by the public in the barrels provided therefor or collected otherwise.

The statistics of the push-cart patrol for the eight years, 1900 to 1907, inclusive, as taken from the books, are given in Table No. 36.

The percentage of increase or decrease in some of the items of this account from 1900 to 1907 have been as follows:

Cost of superintendence and inspection, increase	101	per cent.
Cost of labor and teaming, increase	40	per cent.
Cost of paper patrol, increase	98	per cent.
Cost of holiday pay, increase	183	per cent.
Cost of sundries, increase	39	per cent.
Total cost, increase	55	per cent.
Loads of dirt collected, decrease	12½	per cent.

Table No. 36.

Statistics of the Push-Cart Patrol System, 1900–1907.

YEARS.	Superintendence.	Labor and Teaming.	Snow.	Paper Patrol.	Stock.	Holidays.	Repairs.	Sundries.	Totals.	Barrels of Dirt Collected.
1900	$3,574 10	$41,336 15	$1,985 43	$1,919 50	$1,452 21	$2,225 32	$94 63	$2,113 17	$54,730 51	126,880
1901	4,970 42	47,409 51	5,280 56	3,067 72	1,526 52	5,129 22	67 08	2,480 00	69,996 13	152,210
1902	6,318 84	50,756 99	6,243 81	3,091 11	1,630 54	5,549 89	234 81	3,772 08	77,598 07	150,663
			Miscellaneous.							
1903	7,136 83	49,335 66	$3,996 43	5,199 97	1,325 90	6,504 13	125 65	2,534 76	76,159 22	108,588
1904	7,797 78	50,593 41	3,964 36	4,395 50	1,931 90	5,763 77	131 15	2,641 08	77,218 95	103,272
1905	7,954 88	56,052 82	3,648 50	4,663 83	2,405 17	5,547 65	49 72	2,735 29	83,057 86	100,650
					Plant.					
1906	7,890 21	54,938 35	5,388 45	3,718 00	$2,819 36	4,892 57	—	2,850 79	82,497 73	104,930
1907	7,653 33	57,848 88	6,217 17	3,790 00	99 99	6,397 14	—	2,944 51	84,951 02	112,750

While there is no record of the area cleaned by this force in the different years there is no evidence that, upon the whole, it has increased materially during the period. The fact that the quantity of dirt collected in the district has decreased, while, because of the increase of population it should have increased had the area remained the same, would seem to indicate, if anything, that the area must have decreased.

The decrease in the quantity of dirt collected is surprising, and the only explanation of this anomalous fact seems to be that the efficiency of the force has declined.

There is a wide discrepancy in the ratio of barrels to cart-loads collected as shown below for District 11 alone.

YEAR.	Cart-loads.	Barrels.	Barrels to Cart-load.
1900	6,806	108,213	15.9
1901	6,748	122,663	18.2
1902	7,431	114,080	15.4
1903	5,476	77,509	14.2
1904	5,499	74,056	13.5
1905	5,370	71,157	13.0
1906	6,793	74,865	11.0
1907	6,577	78,186	11.9

The larger number of barrels required to make a cart-load in the earlier years is not explained. It may have been due to counting partially-filled barrels, or the barrels used may have been smaller then. On the other hand, the capacity of the carts is said to have increased considerably during the period. When it is remembered that the standard barrel now holds less than five cubic feet and the standard cart about forty-three cubic feet, even the present number of about twelve barrels to the cart-load is excessive unless the barrels are only partially filled.

But whether we take the number of barrels or of cart-loads the records show that the quantity of dirt collected has decreased during the eight-year period.

A more careful analysis of the quantities of dirt collected by the push-cart patrol force in the various districts was made

in order that no error might arise from confusing the total quantities taken from the reports, and the results are given in Table No. 37. The results agree substantially with those given in Table No. 33, and confirm the conclusion that the total quantity of dirt collected by the push-cart patrol system has decreased 12½ per cent in the eight years.

Table No. 37. — Patrol System.

Total Cost Includes all Charges except Paper Patrol and Snow Removal.

YEAR.	Total Cost as Charged.	Less Paper Patrol and Snow Work.	Net Cost Push-Cart Patrol.	BARRELS OF DIRT REMOVED BY PUSH-CART PATROL.							Cost per Barrel of Dirt Removed.
				District 11.	District 1.	District 2.	District 3.	District 7.	District 10.	Total.	
1900	$54,730	$3,905	$50,825	108,213	3,875	—	1,430	2,791	*10,570	126,879	$0 401
1901	69,996	8,348	61,648	122,663	6,047	647	1,476	7,777	13,573	152,210	405
1902	77,598	9,335	68,263	114,080	13,016	1,245	1,759	8,277	12,286	150,663	453
1903	76,159	5,200	70,959	77,509	8,015	1,178	1,840	8,916	11,130	108,588	654
1904	77,219	4,396	72,823	74,056	7,314	1,010	1,793	7,338	11,761	103,272	706
1905	83,058	4,664	78,394	71,157	6,918	1,164	1,826	7,498	12,090	100,653	735
1906	82,498	3,718	78,780	74,865	8,480	1,247	1,920	6,777	11,640	104,929	750
1907	84,951	3,790	81,161	78,186	12,271	1,207	2,549	8,987	9,549	112,749	720
Totals	$606,209	$43,356	$562,853	720,729	65,936	7,725	14,593	58,361	92,599	959,943	—
Averages	$75,776	$5,410	$70,358	—	—	—	—	—	—	—	$0 632

* Obtained from Annual Report.

The conclusion from all the evidence is that less work is being accomplished by this patrol force now than in 1900, and the increase, 55 per cent in its total cost, requires explanation.

A probable cause for this decreasing efficiency of the force may be found in the great age and decrepitude of the patrolmen. It is stated that their average age is about sixty, and men of that age are naturally incapable of severe, continuous work. Their duties require activity, alertness, and rather hard physical exertion, and they are not able to meet these requirements. Most of them have been, I am informed, in this service for a long period of years. A man's capacity for work of this character declines rapidly after the age of fifty.

While it would not be just to these men, after long years of faithful service to the city, to dismiss them without some provision for their future, it is at least equally unjust to the city to keep them employed at full pay. They should be retired on a small pension and their places filled by strong, active, younger men. Such reorganization of the personnel of this force would, I believe, be better for the present old men, and greatly to the advantage of the city.

A part of the increase of forty per cent in the cost of the item "Labor and Teaming" (see Table No. 36) is doubtless due to the raise in wages, but this will not explain more than ten per cent of it. The holiday pay does not affect the charge for labor and teaming, because this is kept in an item by itself. The increase of over 100 per cent in the cost of superintendence and inspectors is wholly unjustified. As the law relating to holiday allowance has presumably not been changed during the period, the increase of that item of expense to nearly three times what it was in 1900 certainly requires explanation. The increase of over $800 in "Sundries" seems uncalled for. One is also at a loss to account for the fact that seven and three-tenths per cent of the total expenditure for labor and teams in 1907 was for "Miscellaneous" purposes.

Our investigations of the push-cart patrol related mostly to the operations of this branch of the service in 1907 and 1908. It was not possible to go in detail into the pay roll accounts of the whole of either year. A study of the pay roll for August, 1907, and for May and June, 1908, was made in con-

nection with the work done. It was thought that these would give results typical of the two years' operation. The data for each of the three months was collected, classified and tabulated. A condensed statement of them is given in Table No. 38. In this table the average number of men of each class

Table No. 38.

Summary of Expenditures, Push-Cart Patrol, for the Months of August, 1907, and May and June, 1908.

DISTRICT 11.

CLASSES OF EMPLOYEES.	AUGUST, 1907.		MAY, 1908.		JUNE, 1908.	
	Average Number.*	Cost.†	Average Number.*	Cost.†	Average Number.*	Cost.†
Foreman	1	$107 40	1	$118 93	1	$115 06
Clerk	1	84 90	1	84 89	1	82 16
Inspectors	5	391 00	5.5	423 50	4.7	362 75
Patrolmen (push-carts)	50	3,141 02	52	3,110 66	53	3,173 66
Drivers	1	69 75	1	56 25	1	55 13
Hired single teams, carts	5	537 25	3.9	360 50	3.8	353 50
Helpers	1.7	105 75	3	189 00	2.9	177 76
Miscellaneous men	5.9	293 40	3	151 00	2.9	134 75
Extra helpers	3.5	198 00	—	—	—	—
Watchman	1	69 75	1	69 75	1	67 50
Painters	1	73 50	1	75 00	1	73 50
Holiday pay	—	813 95	—	142 75	—	203 23
Number of working days in month	27	—	26	—	26	—
Number of loads of dirt	529	—	409	—	379	—
Cost, total	—	$5,885 67	—	$4,782 23	—	$4,799 00
Cost per load	—	11 13	—	11 70	—	12 66

* This is the average number employed on week days. More or less patrolmen and teams worked on every Sunday.

† This is the full pay roll account for the month, including Sundays, plus the cost of the hired teams, which is not given on the pay roll.

at work on week days is given. Some of the patrolmen, teams and helpers, and inspectors worked on Sundays. The columns headed "Cost" give the full pay roll account for the month, including Sunday pay, and to this has been added the wages of the hired teams which do not appear on the pay rolls.

A study of this table is very interesting.

The pay rolls alone do not show all the expenditures for the work. One-horse teams and drivers are hired to collect and haul away the sweepings, and in 1907 extra helpers were employed with these teams. In 1908 the teams were still hired but the extra helpers were dispensed with. These items were paid for upon bills rendered, and did not appear on the pay rolls.

The total pay roll charges had been cut down from August, 1907, to May and June, 1908, about $1,000 per month, about $600 of which represented decrease in the holiday allowance. But the efficiency of the force had not been increased, since the number of loads of dirt collected decreased in about the same ratio as the pay roll, and the total cost per load was higher in 1908 than in 1907.

The allowance for holiday pay in August, 1907, excites surprise, being about 16 per cent of the total amount of the pay roll for that month. This may possibly be due to the fact that an unusual number of men were given holidays in that month.

Considering the heavy travel carried by the streets that are patrol-cleaned, the very small quantity of dirt collected by the patrolmen in May and June, 1908, is notable. Figuring the cart-load at 43 cubic feet, the total quantity collected in the two months was 33,950 cubic feet. The total number of patrol-days was 2,793, so that the average quantity collected per man per day was less than 12½ cubic feet. This is a much smaller quantity than would be expected from the experience in other cities.

In August, 1907, the whole number of inspectors employed under that name on week days varied from eight in the first week of the month to four in the last week, the average being five. Three inspectors were on duty one Sunday and two on each of the other Sundays, although the number of patrolmen at work on three of the Sundays was only seven.

In addition to these there were employed under the head "Miscellaneous" two "provisional" and one "barrel" inspector, so that the actual number employed varied from eleven to seven.

In May and June, 1908, the regular inspectors varied from

four to six. But even in these months there was, upon an average, one inspector to about ten patrolmen. In addition to the general supervision of the foreman, one inspector to twenty patrolmen should be sufficient under present methods of inspection.

It will be noted that on the August, 1907, pay roll there were constantly employed from five to six men under the head of "Miscellaneous." These, upon inquiry, were found to be the following:

2 provisional inspectors.
1 barrel inspector.
1 yardman.
1 dumpman.
1 office boy.

These inspectors were in addition to the large number employed under that head. The yardman assisted the painter, cleaned tools and performed other miscellaneous work. Considering the small quantity of material sent to any one dump, a dumpman would seem unnecessary. It is difficult to understand why an office boy was necessary.

On the sheets for May and June, 1908, the "Miscellaneous" force had been reduced to a dumpman, a yardman and an office boy.

SPECIAL STUDY.

The apparent inefficiency of the push-cart patrol and the high cost of the work accomplished by it suggested that a more careful and special examination should be made into that branch of the service.

It was therefore decided to select at random a considerable number of patrol routes, to be studied more in detail. Thirty-seven of these routes, believed to be typical of the whole work, were chosen, and assistants were sent out to observe and record the progress and results of the work.

The limits of the routes selected were obtained from the office records, and the areas of each route determined upon that basis as accurately as practicable. In many cases, however, the patrolmen did not sweep the whole of this prescribed route on the day observed, and in these cases only the areas actually cleaned were considered.

Usually one day's work on each route was observed and recorded. As the density of travel on each route is a matter of importance, the observers were directed to record the character of the traffic and to count the number of horses passing a fixed point in a given time — usually one-half hour or one hour. The time of day when the count was made was selected so as to give approximately the average rate of travel for the day. The number of horses recorded in the time observed was reduced to the basis of the number passing in a ten-hour day, and the number thus computed was entered in the proper column of the table. The quantity of dirt collected by each patrolman was obtained by actual measure as it was found in the barrels. The number of times the patrolman covered his route during the day was also noted and recorded.

In compiling the information thus collected it was found that only twenty-seven of these routes were fairly comparable with each other, and the others were discarded. These twenty-seven routes were tabulated and collated, using the areas actually swept, and the results are shown in Table No. 39.

In comparing the work of one patrolman with another it must be remembered that some pavements are more difficult to clean than others. The smooth pavements, asphalt, wood-block and bitulithic, do not differ much in this respect, but granite-block pavement requires about 1.4 times as much labor to clean it equally well as the smooth pavements. In order to make the work done by the different men fairly comparable the area of granite pavement on each route was multiplied by 1.4 and a column headed "Equated Totals" constructed to show the relative area of the routes cleaned. In other words, allowance was made for the greater labor of cleaning the granite block pavements, so as to reduce the work done by each man to a fair basis for comparison. The number of times each patrolman was observed to go over his route during the day was noted, and the equated area multiplied by the number of times the route was gone over gives the number of square yards purporting to be cleaned daily by each man, as shown in the table. Little weight should, however, be attached to the areas thus obtained,

Table No. 39.

Observations on Patrol Street Cleaning, District 11, Made in July, August and September, 1908.

Routes.	Length of Route. Feet.	Area Cleaned as Observed.				Route Cleaned.		Square Yards Cleaned Daily. Per Man.	Character of Travel.	Horses Passing Ten Hours.	Dirt Collected. Cubic Feet.	Dirt Collected Per 1,000 Square Yards.‡
		* Smooth Pavements.	Granite.	Total.	Equated Total.	Times Daily.	Manner.					
2	1,200	—	3,049	3,049	4,300	4	Well.	16,200	Medium.	1,900	9	2.95
3	502	1,736	—	1,736	1,736	7½	"	20,832	"	3,780	12	6.92
4	667	2,450	—	2,450	2,450	7½	"	18,370	"	3,780	16.5	6.74
5	400	1,802	—	1,802	1,802	6½	"	11,700	"	5,360	12	6.66
6	750	3,400	—	3,400	3,400	6½	"	22,100	"	5,360	15	4.42
7	500	2,277	—	2,277	2,277	6½	"	14,800	"	5,360	15	6.59
8	1,060	—	4,711	4,711	6,600	4	"	26,400	Heavy.	3,850	14.6	3.10
9	600	1,404	556	1,960	2,182	5 †	Fair.	8,835	"	3,450	14.6	7.45
10	1,843	7,353	—	7,353	7,353	4	Well.	29,412	Light.	580	13.5	1.84
11	2,000	7,230	4,257	11,487	13,190	4½	Fair.	59,300	"	2,150	17	1.48
15	1,500	2,592	1,122	3,714	4,163	5	Well.	20,815	Medium.	2,350	13.5	3.64
17	500	1,404	185	1,589	1,662	5	"	8,310	"	3,450	14.6	9.20
18	1,800	9,739	2,283	12,022	12,939	5	"	64,695	Light.	1,460	12	1.00
20	3,250	9,588	478	10,066	10,258	4	"	41,032	"	1,780	19.4	1.93
23	1,720	9,143	—	9,143	9,143	4½	"	41,144	"	930	17	1.86
25	1,500	—	6,396	6,396	8,960	3	Fair.	26,900	Heavy.	4,130	12.1	1.90
26	700	3,758	797	4,555	4,873	5	Well.	24,365	Medium.	1,840	13.5	2.97

Table No. 39.—*Continued.*

27	2,400	2,091	3,329	5,420	6,750	4	"	27,000	"	1,840	11	2.03
28	1,540	3,344	1,534	4,878	5,490	6½	"	35,700	"	2,300	13.5	2.77
29	623	4,825	—	4,825	4,825	6	"	28,950	"	4,300	22	4.56
30	675	2,636	—	2,636	2,636	12	"	31,632	"	5,640	18	6.83
31	1,118	5,754	753	6,505	6,808	7	"	47,656	Light.	3,080	15	2.31
32	1,362	6,654	1,800	8,452	9,175	8	"	73,400	"	3,080	15	1.77
33	1,324	7,355	—	7,355	7,355	3	"	22,065	"	2,470	12	1.63
34	2,780	2,116	6,976	9,092	11,881	6	"	71,286	Medium.	1,600	10.5	1.15
35	2,900	7,029	4,995	12,024	14,020	4	"	56,080	"	2,970	10	0.83
37	1,021	2,135	2,523	4,658	5,665	4 †	"	12,070	Heavy.	4,120	16	3.44
Totals	36,235	107,815	45,744	153,559	171,839	—	—	—	—	—	384.3	—

*Asphalt, wood-block and bitulithic. † Part of this cleaned once only. ‡ In cubic feet.

since a patrolman might pass over this route several times carelessly without doing as much effective work as he might have done by going over it more thoroughly half the number of times. The result is valuable, however, in showing the apparent absence of systematic regulation of the work.

A study of this table will be very instructive, and will throw some light upon the present inefficiency of this patrol service, and its great cost as measured by the work accomplished. These twenty-seven routes cover 36,235 feet in length of streets, about 6.9 miles. The average length of street cared for by each man is therefore slightly over ¼ mile. The actual area of pavement on the twenty-seven routes is 153,559 square yards, or 5,687 square yards per man. This is probably more than one man can properly care for, on the average, in the heavy traveled part of a large city. But in comparing the areas of the different routes we are struck by the wide variation in the work assigned to the different men, and when we compare the areas with the character of the streets the difference appears even more notable. The work of keeping a street clean is, roughly speaking, in the ratio of the amount of travel over it. The heavier the travel the smaller should be the area assigned to a patrolman. But no such considerations seem to have controlled the distribution of the men in this case. The "equated" areas of the routes vary from less than 2,000 square yards to over 14,000 square yards. It is difficult to understand the basis upon which the assignment of routes is made. Thus, route 3 covers Tremont street from School street to Scollay square, the actual area of which is 1,736 square yards; route 4 covers Tremont street from School street to Park street, the area of which is 2,450 square yards, or 40 per cent more than route 3. Route 6, Tremont street from Temple place to Keith's Theater, covers 3,400 square yards. These three routes adjoin each other on the same street, they are all paved with smooth pavement, and carry about the same density of travel. Yet one of them covers about twice the area of another, and the smallest is too much for one patrolman on this part of Tremont street, if he be expected to keep it reasonably clean.

There is also seen to be a considerable difference in the quantity of dirt collected daily on the different routes, which varies from 9 to 22 cubic feet. The quantity collected per 1,000 square yards of pavement varies widely, as might be expected from the wide variation in density of travel, but is in most cases abnormally small. This may be illustrated by the results of similar investigations in other cities. Thus, the Commission on Street Cleaning and Waste Disposal in New York made a like investigation on a number of patrol-cleaned downtown streets in New York in the summer of 1907, with the following results:

STREET.	Cubic Feet Per Man.	Collected Per Day Per 1,000 Square Yards.
Broadway, Seventeenth street to Twentieth street	23.3	9.2
Bowery, Rivington street to Houston street	52.6	13.1
Warren street, Broadway to West Broadway	46.4	15.4

These streets are not more heavily traveled than Tremont street (routes 3 and 4) or Federal street from Milk to High (route 8) in Boston, which yielded respectively 6.92, 6.74 and 3.10 cubic feet per thousand square yards. The fact that these Boston streets were machine swept at night, while the New York streets were not, would account for a part of this difference; but if the streets were well cleaned during the day not very much dirt would accumulate after 5 p. m. to be removed by the machine at night, and the patrolman should, therefore, collect much the greater part of the total dirt from the street.

REMOVING AND DISPOSING OF SWEEPINGS.

Four single-horse carts were employed to haul away sixteen loads per day, each cart making apparently four loads per day. The average length of haul seems not to have exceeded about one mile. As each driver has an assistant to help him load, there is good reason to believe that three carts could handle this work without difficulty.

The necessity or propriety of providing a helper for each of these carts is at least open to question. The barrels and cans now used in Boston are, when filled with dirt, too heavy for one man to handle. Smaller and lighter metallic vessels which one man could handle readily might be advantageously substituted. But while the present large vessels are in use there is no reason why the patrolmen should not assist the driver in loading, particularly as each patrolman does not usually have more than four or five cans per day to remove. The helper is certainly not needed by the driver for any purpose other than loading, and is presumably idle the greater part of his time.

These and like considerations, not necessary to detail here, and personal observations on the streets, convince me that this patrol work is poorly organized and badly managed, and as a result the force is inefficient, and its cost, measured by the results obtained, is excessive.

The present practice of cleaning the same streets by hand during the day and by machine at night seems to me unnecessary and inadvisable. It is usually more expensive and not so satisfactory, assuming that the work be equally well done, as would be patrol sweeping alone, and it divides the responsibility for keeping the streets clean. But the patrol routes should then be shortened so that each patrolman could keep the area assigned to him properly cleaned. At present the routes in the central, heavily traveled streets are much too long to permit a single man to keep them in proper condition. Thus the stretch of Tremont street from School street to Boylston street, having an area of over 11,500 square yards, should probably be divided between ten patrolmen instead of five as now. These ten could keep the street in much more satisfactory condition than it is now, could be held responsible for doing so, and no machine sweeping would be necessary. The cost would be somewhat higher, but the greater cleanliness of the street would fully justify the additional cost.

A thorough overhauling and reorganization of the push-cart patrol service seems to be necessary to secure satisfactory results.

1. A readjustment of the routes so as to give each patrolman substantially an equal amount of work to do should be the first step in this reorganization. It is not probable that the average area of pavement per man can be increased, and the routes on the heaviest traveled streets should undoubtedly be materially decreased in area. Practical trials may be necessary in many cases to ascertain what area in each particular location a man may be reasonably expected to care for.

2. The present force should be reorganized by relieving the men who are too old to render satisfactory service and their places filled by strong, competent, young men. More and better work should then be required of the men than the city is now receiving.

3. In the great majority of cases, at least, patrol cleaning and night machine cleaning of the same streets should be discontinued. The routes should be so adjusted that each patrolman might reasonably be required to keep his route satisfactorily clean.

4. With the routes equitably adjusted the efficiency of the men might and should be judged by the results; that is, by the condition in which each keeps the route assigned to him. This means that the men are not to be watched to see when they are at work or the vigor with which they work, but that the work accomplished is itself to be regarded as the standard of their performance.

5. Under such a system only a small inspection force would be necessary. Two inspectors in addition to the foreman should be ample. The length of streets cared for by the patrol force does not exceed nineteen miles, and two inspectors could cover this daily, noting the condition of each patrolman's route, including the promptness of the carts in removing the dirt collected.

6. The collecting and disposing of the street dirt should also be reorganized. Where four carts are now employed three should be sufficient. The helpers now attached to these carts should be dispensed with, the patrolman giving the drivers such aid as may be necessary.

7. The three or four men now employed on "Miscellane-

ous" work would seem to be largely unnecessary, and should be dispensed with except where their services are found absolutely necessary. In any event their services should be charged to some appropriate account. An office boy, for instance, should be charged to the office of the foreman.

If the patrol work were reorganized along these lines and properly administered not only should the cost be materially reduced, but the streets ought to be kept much cleaner than they are now.

MACHINE SWEEPING.

The average cost of sweeping once, by machine, a mile of paved street, for the eight years 1900 to 1907, inclusive, as shown by the annual reports, has been $10.26 and a comparison of this figure with the cost for each year (Table No. 33) shows that it has not varied much above or below the average, but this uniformity does not prove that the cost is reasonable.

It was thought important to look into the subject of machine sweeping a little more carefully than the data in the annual reports makes possible.

Some streets are swept every day, others every other day, some every third or fourth day, and some only once per week. The actual miles of street cared for are not, therefore, a correct measure of the work done. The unit usually used is *miles of streets swept once*. This means that if the same mile of street is swept six times during the week it is equivalent to six miles of street swept once. Wherever the term per mile is herein used in speaking of machine sweeping it refers to one mile swept once. The quantities in Column 4 of Table No. 33 have this meaning.

The cost per mile of machine sweeping in different cities varies with the conditions in that city, and unless all these conditions in detail are known no fair comparison of cost can be made. One of these conditions is the relative width of streets. A machine may sweep a path six feet wide, but in operation some lap of one path over another is necessary, and even with careful work the effectual path will not be more than 5½ feet. But unless the width of the street is an even multiple of 5½ feet the machine must sweep at

least one path less than 5½ feet in order to cover the full width. Thus, if the roadway be 30 feet wide, a machine must make six trips over it to cover the whole surface, although the last trip may be necessary to sweep a strip only 2½ feet wide. Theoretically, a machine with a six-foot swath should sweep about 8,000 square yards per hour, or 64,000 square yards in 8 hours. But in practice so large an amount of work is seldom accomplished. We found that the average area swept in District 8, downtown, per 8 hour day, is about 51,000 square yards, and considering the narrowness of many of the streets and other conditions, this is probably a fair day's work.

The records of the department are kept in *miles* of streets cleaned and not in square yards of area. The department has not determined and does not know the area swept, and as the streets vary greatly in width the records kept do not give a fair basis for comparing the work actually done. Furthermore, a considerable part of the work consists of sweeping the paved gutters of macadam streets, and while these gutters vary in width from 3 to 4 feet a machine, in covering them, must actually do the same work as would be required were the gutters 6 feet wide. The city records of miles of paved streets and of gutters swept do not, therefore, give a correct measure of the work accomplished, and are of little value in determining the efficiency and economy of the work done.

Table No. 40 gives, from the department records, the miles of paved streets cared for in each district, the miles of macadam streets on which the gutters only are swept, and the total area in square yards cared for by the department. The areas of the paved streets are computed on the basis of 20,900 square yards per mile, and the two gutters on the macadam streets are figured as requiring 12 feet wide of sweeping, or 7,040 square yards per mile of street.

In the absence of any record of the areas swept once during each of the eight years an attempt was made to determine these areas as closely as practicable. It was found from the records in the Paving Division that the average area per mile of the paved streets in the city was very nearly 20,900 square

yards, and this factor was, therefore, used in converting miles into areas. While the results are not accurate they doubtless are within a small percentage of the truth.

Table No. 41 gives the areas machine swept each year determined in this way, and the deduced cost of sweeping per 1,000 square yards each year for the whole city. It will be noted that this cost has been very uniform for the eight years.

Table No. 40.

Miles and Areas of Streets Cared for by Street Cleaning Department (Approximate).

District Number.	Location.	Miles of Street Cared for.		Square Yards Cared for.		
		Paved.	Macadam.	Paved Streets.	Gutters 12 ft. Wide.	Total.
1....	South Boston.....	20.19	17.82	424,000	125,500	549,500
2....	East Boston.....	7.21	19.23	154,000	135,400	289,400
3....	Charlestown.....	12.91	11.60	293,000	81,700	374,700
6....	Dorchester (part).....	5.29	24.32	109,000	171,200	280,200
7....	Roxbury.....	17.32	9.29	383,000	65,400	448,400
8....	South End (uptown).....	11.16	12.01	225,000	84,500	309,500
8....	South End (downtown)....	28.20	1.22	570,000	8,600	578,600
9....	Back Bay.....	12.46	18.00	252,000	126,700	378,700
10....	North End.....	9.35	.94	189,000	6,600	195,600
10....	West End.....	11.48	—	232,000	—	232,000
	Totals.....	135.57	114.43	2,831,000	805,600	3,636,600

Table No. 42 gives the cost per mile cleaned once in each district for the eight years, 1900 to 1907, inclusive, as obtained from the records of the department. While of interest in showing the wide variation in results it would not be fair to conclude that the efficiency and economy in the several districts varies so widely as indicated, although one's curiosity is aroused as to why the cost of sweeping per mile should vary so much in the several districts. Thus in District 8, downtown, the average cost per mile for the eight years appears to have been $7.34, while in District 8, uptown, the average cost was $11.73. There are no apparent reasons for so wide a difference. Nor is it apparent why the average cost per mile

Table No. 41.

*Statistics of Street Cleaning (Exclusive of Push-Cart Patrol).**

YEAR.	SQUARE YARDS MACHINE SWEEPING.			COST OF MACHINE SWEEPING.			COST PER 1,000 SQUARE YARDS.		
	Paved Streets.	Gutters Swept. 6 Feet Wide.	Total.	Paved.	Gutters.	Total.	Paved.	Gutters.	Total.
1900	298,400,000	23,100,000	321,500,000	$149,659	$25,369	$175,028	$0 502	$1 098	$0 544
1901	246,700,000	17,300,000	264,000,000	128,132	19,760	147,892	520	1 142	560
1902	271,200,000	17,800,000	289,000,000	127,741	19,645	147,386	472	1 104	510
1903	274,300,000	18,600,000	292,900,000	133,028	18,312	151,340	485	985	517
1904	256,200,000	20,200,000	276,400,000	125,576	18,557	144,133	490	919	522
1905	284,500,000	25,000,000	309,500,000	133,842	20,171	154,013	470	808	498
1906	307,100,000	26,700,000	333,800,000	145,778	20,674	166,452	475	774	499
1907	302,300,000	28,000,000	330,300,000	156,038	23,797	179,835	516	850	544
Totals	2,240,700,000	176,700,000	2,417,400,000	$1,099,794	$166,285	$1,266,079	—	—	—
Averages	—	—	302,200,000	—	—	$158,200	$0 491	$0 941	$0 524

* Miles are reduced to yards by average value of 20,900 square yards per mile, obtained from table given in Annual Report of Street Cleaning Division.

NOTE.— Macadam streets with paved car tracks are considered as paved streets, though only the paved area is swept. Macadam streets in sections mostly paved are often included with the paved streets both as to area and cost. Cost given does not include cost of city horses.

in District 7 should have been so high as $19.52, or about 2.6 times as great as in District 8, downtown. (The cost of the city horses is not included in these costs.) If we knew the actual areas of streets cleaned and other conditions it might be possible to analyze the figures satisfactorily.

Table No. 42.

Showing Cost per Mile of Cleaning Paved Streets by Years and by Districts. (Figures from City Records.)

District Number.	Cost Per Mile of Paved Streets Cleaned Once.							
	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
1.....	$13 81	$15 82	$19 12	$21 64	$21 35	$16 04	$15 76	$12 78
2.....	11 75	13 13	14 24	12 21	16 35	13 95	15 20	13 80
3.....	12 77	13 45	12 58	12 50	13 18	11 92	11 77	12 86
6.....	—	—	—	—	23 22	25 86	23 73	37 75
7.....	18 96	21 08	17 95	18 78	19 13	19 06	18 88	22 31
8, D.T.,	8 05	8 16	6 89	7 32	6 87	6 90	7 06	7 51
8, U.T.,	11 58	13 74	12 73	11 75	11 13	10 62	10 67	11 61
9.....	11 92	11 06	12 03	8 94	8 86	7 36	7 68	8 10
10, W.E.,	9 14	8 02	6 98	7 31	7 56	7 60	7 60	8 54
10, N.E.,	Included in 10W.E	9 64	8 59	9 15	9 23	8 86	9 46	10 05
Averages,	$10 48	$10 75	$9 74	$10 03	$10 05	$9 66	$9 74	$10 60

In this table the miles of gutters cleaned in Districts 8, downtown, and 10, West End, have been combined with miles of paved streets cleaned. In these cases there was no labor charged for work on gutters.
Does not include cost of city horses.

Table No. 43 gives, from the records, the cost of sweeping gutters for each district during the same period of years. (In some of the districts the gutter sweeping for at least a number of years was not kept separate from the sweeping of paved streets.) A mile of street in this table means the cleaning of the gutters on each side, or two miles of gutter. Here we can get at the facts more satisfactorily, for to clean the two gutters on a mile of street the sweeping machine must travel two miles regardless of the width of the gutters, which are never equal to that of the full path of the machine. The wide differences in cost are, therefore, the more surprising and seem to demand careful investigation. It is impossible to

understand why, for instance, the average cost of sweeping per mile of street (or two miles of gutter) for the eight years should have been $7.60 in District 8, uptown, and $15.40 in District 7, or why the cost in this district should have varied from $21.68 in 1900 to $5.20 in 1907. The conditions in this gutter sweeping work are so nearly the same that the cost per mile should be practically uniform. But even so late as 1907 this cost per mile varied from $3.59, to $9.28, or nearly 300 per cent. The data procurable does not make possible an analysis of these costs for past years, but the department should certainly look into the present conditions very carefully.

Table No. 43.

Showing Cost per Mile of Cleaning Gutters by Years and by Districts.
(Figures from City Records.)

District Number.	Cost per Mile of Streets for Gutters Cleaned Once.							
	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
1.....	$2 94	$4 27	$5 54	$4 34	$3 98	$3 20	$2 88	$3 59
2.....	6 93	6 90	5 66	6 16	5 84	6 05	6 48	8 88
3.....	7 06	7 62	7 62	6 26	6 46	6 78	6 97	6 70
6.....	—	—	—	—	7 09	5 84	5 61	5 57
7.....	21 68	23 04	19 35	16 26	14 44	10 35	12 78	5 20
8, D.T.,	2 14	2 02	0 29	0 49	Combi	ned with	paved st	reets.
8, U.T.,	7 96	7 55	8 05	8 89	7 96	6 94	6 82	6 65
9.....	9 29	9 40	11 91	10 65	9 35	8 58	7 87	9 28
10, W.E.,	—	—	—	—	—	—	—	—
10, N.E.,	—	—	—	—	—	—	—	—
Averages,	$8 00	$8 43	$8 26	$7 38	$7 04	$6 08	$5 88	$6 40

Does not include cost of city horses.

In order to investigate and if possible reconcile these wide differences in cost in the different parts of the city we have gone more into detail with the work of the department in 1907. The large discrepancies in the comparative cost of sweeping paved streets and sweeping gutters was thought to be possibly due to some confusion in recording the quantities of each. It was, therefore, thought best to combine them upon an equitable basis and to determine the cost of the

combined service. Table No. 44 gives these combined results. In forming this table the miles of paved streets swept once as given in the records were used, and these were reduced to square yards, using the average number of yards per mile as nearly as this factor could be determined for each district. In determining the area of gutters cleaned, the miles cleaned once were used, and it was assumed that since each gutter required the passing of the sweeping machine, equivalent to sweeping a strip 6 feet wide, the sweeping of the gutters on one mile of street was equivalent to sweeping a strip one mile long and 12 feet wide. The gutter areas thus determined were added to the areas of the paved streets to find the total area swept once in the district. The cost of sweeping both the paved streets and the gutters was also combined to get the entire cost of the whole service.

The areas of paved streets swept once as shown by this table do not agree exactly with the quantity shown for 1907 in Table No. 41 because of the different method used in determining them, but the difference is only about 1 per cent and does not affect the general results.

To obtain the full cost of the work the cost of maintaining the city horses has been added to the pay roll charges. The table gives the cost of cleaning once per thousand square yards and per mile, also the total number of loads of dirt collected and the loads per thousand yards swept.

It will be noticed that even when the work done is thus combined there are wide differences in the derived unit cost of the work in the different districts. Thus, for District 8, downtown, the cost per mile was $9.08 and the cost per thousand square yards was 45 cents, while for District 6 these respective figures were $26.06 and $1.26. In other words, machine sweeping in the latter district cost nearly three times as much per unit area as in the former. Between these extremes the costs for the different districts vary widely, as shown by the table. The records of the department offer no explanation of these wide differences, nor is the department itself able to account for them. They should be carefully investigated by the department and if they are found to result from differences in the efficiency of adminis-

Table No. 44.

Street Cleaning by Districts (Exclusive of Push-Cart Patrol) for the Year 1907.

District Number.	Paved Streets.			Two Gutters.		Total Thousands of Square Yards Cleaned Once.	Cost for Both Streets and Gutters.			Cost per Thousand Square Yards Cleaned Once.	Cost per Mile Cleaned Once.	Loads of Dirt Removed.	
	Miles Cleaned Once.	Average Thousands of Square Yards per Mile.	Thousands of Square Yards Cleaned Once.	Miles Cleaned Once.	Thousands of Square Yards.*		Total Pay Roll.	Estimate Cost, City Horses.	Total Cost.			Total.	Per Thousand Square Yards.
1.....	1,527	21.0	32,090	837	5,890	37,980	$22,519	$6,784	$29,303	$0 77	$16 20	2,153	.57
2.....	467	21.3	9,950	484	3,410	13,360	10,749	3,235	13,984	1 05	22 30	8,258	.62
3.....	958	22.7	21,750	420	2,960	24,710	15,131	2,739	17,870	. 72	16 41	9,993	.40
6.....	172	20.6	3,540	848	5,970	9,510	11,215	812	12,027	1 26	26 06	8,988	.94
7.....	855	22.1	19,900	94	660	20,560	19,575	2,042	21,617	1 05	23 28	8,960	.43
8, U.T....	1,152	20.2	23,290	435	3,060	26,350	16,267	4,035	20,302	77	15 58	10,596	.40
8, D.T....	5,076	20.2	102,500	108	760	103,260	38,959	7,453	46,412	45	9 08	21,307	.20
9.....	710	20.2	14,340	601	4,230	18,570	11,319	1,891	13,210	71	14 35	5,394	.29
10, W.E...	1,847	20.2	37,320	148	1,040	38,360	17,033	5,938	22,971	60	12 10	8,343	.22
10, N.E....	1,698	20.2	34,300	—	—	34,300	17,069	6,027	23,096	67	13 58	8,930	.26
Totals...	14,462	—	298,980	3,975	27,980	326,960	$179,836	$40,956	$220,792	—	—	112,522	—
Averages,	—	20.9	—	—	—	—	—	—	—	$0 675	$14 12	—	.345

* Counting each gutter swept six feet wide.

tration suitable remedies should be applied. The last column of the table gives the reported loads of dirt removed per thousand square yards swept. There are variations here also, but these differences may be, at least partly, due to explainable causes. Thus, District 6 shows much the largest quantity. In this district nearly 60 per cent of the whole area swept consists of the gutters of macadam streets, and the dirt from the whole street tends to collect in the gutters, where the machines take it up. Furthermore, the detritus from the wear of macadam streets, even though the travel be light, is much greater than from paved streets. District 8, downtown, shows the smallest quantity collected, but a large area of its streets are covered by the push-cart patrol which is supposed to remove the dirt accumulating through the day, which should be much the largest part of the whole. The figures in this last column are valuable as indicating the relative cost of disposing of sweepings as affecting the total cost of the work.

A similar study of the accounts for the five months, January 24 to June 25, inclusive, 1908, was made and the results are given in Table No. 45. A comparison of this table with Table No. 44 (which gives the results for the whole year 1907) shows that the conditions were not materially changed in the first half of 1908. Apparently the average area cleaned was somewhat increased; thus, the average area cleaned per month in 1907 was 27,241 square yards, while the average for the five months in 1908 was 27,662 square yards. But the cost of the work per thousand square yards cleaned seems to have remained the same.

Referring to the comparative results in the several districts, as shown by the last two tables, there appear differences that are difficult to account for, unless they be due to inaccuracies in the records and accounts. There is no known reason, for instance, why the cost of cleaning per thousand square yards should have increased 16 cents in District 7 and decreased 23 cents in District 6 in 1908. In District 8, downtown, where the conditions all seem to favor careful accounting and uniform work, the cost in 1908 is 1 cent per thousand square yards higher than in 1907.

Table No. 45.

Street Cleaning by Districts in 1908. Five Months, January 24 to June 25.

District Number.	Miles of Paved Streets Cleaned Once.	Average Thousand Square Yards per Mile.	Thousands of Square Yards Paved Streets Cleaned Once.	Miles of Gutters Cleaned Once.	Gutters. Thousands of Square Yards Cleaned on Basis 6 Feet Wide.	Total Thousands of Square Yards Cleaned Once.	Total Pay Roll and Hired Teams.	Estimated Cost of City Horses.	Total Cost.	Cost per 1,000 Square Yards.	Cost per Mile.	Total Loads of Dirt Removed.	Loads of Dirt per 1,000 Square Yards.
1.....	550.59	21.0	11,560	240.02	1,690	13,250	$8,460	$2,185	$10,645	$0 80	$16 87	7,498	.56
2.....	245.24	21.3	5,220	255.18	1,800	7,020	5,219	1,473	6,692	95	20 31	3,400	.48
3.....	423.92	22.7	9,620	145.64	1,030	10,650	5,716	1,271	6,987	66	14 90	3,933	.37
6.....	97.12	20.6	2,000	225.37	1,570	3,570	3,415	281	3,696	1 03	21 32	1,973	.55
7.....	308.22	22.1	6,810	57.85	410	7,220	7,721	1,043	8,764	*1 21	26 82	3,382	.47
8, U.T....	461.81	20.2	9,310	140.95	990	10,300	7,062	1,795	8,857	86	17 35	3,578	.35
8, D.T....	2,257.38	20.2	45,600	48.34	340	45,940	17,741	3,316	21,057	46	9 25	7,242	.16
9.....	242.88	20.2	5,910	220.43	1,550	7,460	4,708	849	5,557	74	15 05	1,972	.26
10, W.E....	840.61	20.2	16,970	61.99	440	17,410	7,829	2,767	10,596	61	12 29	3,661	.21
10, N.E....	766.38	20.2	15,490	—	—	15,490	7,797	2,731	10,528	68	13 71	3,577	.23
Totals...	6,244.15	—	128,490	1,395.77	9,820	138,310	$75,668	$17,711	$93,379	—	—	40,166	—
Averages,	—	20.9	—	—	—	—	—	—	—	$0 675	$14 10	—	.290

* No work reported for three weeks, although charge made of $500.

My personal observations, which were limited in extent, are to the effect that the work is more thoroughly done now than it was in 1907, and this fact would be sufficient to explain the apparent slight increase in the cost of the work. Upon the whole the work in 1908 seems not to have changed materially either in quantity or cost.

To have made a careful detailed study of machine sweeping conditions throughout the whole city would have involved an amount of time and expense that the commission's instructions did not warrant.

Two districts were, therefore, selected, No. 8, downtown, and No. 8, uptown, and the pay roll accounts of these for a period of ten weeks, May 29 to August 6, 1908, were looked into. The actual field work in the two districts was also looked into in connection with the accounts. The areas actually cleaned once were determined as accurately as possible from the data available.

District 8, Downtown.

This district is roughly bounded by Dover street and Fort Point channel to State street and an irregular line from Scollay square through Park square to Dover. It embraces nearly the whole of the downtown shopping and about one-half of the business district. The South Station is in this district, and the travel on the greater part of the streets is very heavy.

All the machine sweeping and the collecting of dirt is done during the night, except during the winter months. The study of this district is based practically on the reports of the department rather than on original investigation. Figures furnished by the department for 1907 show that there are 30½ miles of streets cared for in this district, some of which are swept as many as six times per week, the total length of street swept once being 124 miles per week. These figures are, however, based on the mileage of streets in the district rather than upon the mileage actually swept, which is difficult to obtain. The area of the streets cared for is about 530,000 square yards. Of this, about 29 per cent is cleaned six times per week, 21 per cent five times, 31 per cent three times and the remainder once or twice.

Embraced in the district are about 11,000 square yards of macadam street, along which the gutters only are swept. No distinction is made in the accounts of the cost, however, in sweeping these streets and the paved streets. The amount of macadam street is, however, so small as to not affect materially the accounts for the work in the whole district.

In sweeping the gutters the machine is run along each gutter, the broom being so tilted that only so much of it is brought into use as will cover the width of the gutter, which never exceeds 4½ feet.

The daily reports show that the force employed averages about 43 men, though there were usually about two men absent without pay.

A typical distribution of the force would be as follows:

1 foreman.
4 inspectors.
8 two-horse sweeping machines with drivers.
2 one-horse watering carts with drivers.
16 men following the sweepers with brooms.
12 single teams and carts with drivers.
12 team helpers.
1 dumpman.
1 to 3 miscellaneous men.

The horses used with the sweeping machines and watering carts belong to the city. Those used with the collecting carts are hired, the rate being $3.50 per day for one horse and driver. The carts belong to the city, but are now kept in repair by the contractor who supplies the horses.

The area of streets swept daily averages about 400,000 square yards, including gutters, the average swept per machine per day being about 51,000 square yards.

The machines actually work about seven and one-half hours per night, the other half-hour being occupied in going to and from stables.

During the ten weeks, May 29 to August 6, 1908, the total pay roll charges amounted to $8,297.82, distributed as shown by Table No. 46, where the cost of sweeping proper and that of collecting and disposing of the sweepings has been separated as nearly as practicable upon the basis that the sweeping included the collecting of the sweepings into piles in the gutters, ready

to be taken up and hauled away; but the pay rolls do not show the cost of the city horses employed on the work and this has been added to get at the total cost.

During this ten weeks' period the total area swept once was about 22,250,000 square yards, counting the macadam gutters as being swept for a width of 4½ feet.

Table No. 46 shows both the cost of sweeping and of disposing of the sweepings per thousand square yards, the total amounting to 45.5 cents.

Table No. 46.

Cost of Street Sweeping (Machine), District 8, Downtown, for a Period of Ten Weeks, May 29 to August 6, 1904. Data from Actual Weekly Pay Rolls.

ITEMS.	Total Number of Days Employed.	Cost Machine Sweeping.	Cost Collecting Sweepings.
Foreman	70	$121 50	$147 00
Inspectors and sub-foremen	212	278 70	358 80
Sweeping machine drivers	436	981 00	—
Watering cart drivers	103	231 74	—
Sweepers and bunchers	849½	1,911 36	—
Shovelers and loaders	597½	—	1,344 34
Hired teams and drivers (single)	645½	—	2,259 25
Dumpman	55	—	123 75
Tallyman	16½	—	41 25
Holiday pay	—	336 50	162 63
Total pay roll, including team	—	$3,860 80	$4,437 02
Add city horses at $1.70 per day	1,068½	1,816 45	—
Total cost	—	$5,677 25	$4,437 02

Area swept once, square yards	22,250,000
Cost per thousand square yards, sweeping	$0 255
Cost per thousand square yards, collecting	200
Cost per thousand square yards, total	$0 455
Number of sweeping machine days	436
Square yards per day per machine, average	51,046
Number of loads sweepings collected	3,190
Cost of collecting sweepings per load	$1 39
Number of cubic feet sweepings collected	137,100
Cubic feet per thousand square yards	6.18

Referring to Table No. 44 it will be seen that the average cost for the whole year 1907 in this district, as derived from

the department records, was 45 cents per thousand square yards. The close agreement of these independent determinations seems to confirm their accuracy.

The quantity of dirt, collected per thousand square yards appears very small. This is partly due to the fact that the push-cart patrol collects during the day a large part of the dirt on many of the streets.

It was found that there were, in the total actual area of pavement cared for and cleaned in this district, and embraced in the figures above, 19,625 square yards of paved and 1,346 square yards of macadamized private ways. No law making it the duty of the city to clean these private ways was brought to our attention, but it is presumed that this work was not done without legal authority. On some of these property owners pay something to the city for this work.

It will be noted that the compensation for the use of city horses amounts to a large item in the total cost of the sweeping. It will be shown, further on, that the actual cost of these horses to the city amounts to $1.70 per day, the rate charged in this account. In the accounts of the department this item is covered in the account "Stable and Yard Expenses," but in ascertaining the itemized cost of the work done the cost of the city horses should be properly distributed to the various kinds of work.

Personal observations by myself and assistants showed that the work in this district was well done, the streets being cleanly swept, the dirt being immediately collected into piles in the gutters and removed during the same night. The force seemed to be well organized and controlled and all employees seemed to work industriously and intelligently. The foreman impressed me as a very competent man, deeply interested in his work.

District 8, Uptown.

This district is roughly bounded by Dover street, Fort Point channel and South bay, Norfolk, Hampton and Lenox streets, New York, New Haven & Hartford Railroad, and Berkeley street. The district comprises most of the lodging

house district, also a large number of coal and lumber dealers on Albany street, and many of the cheaper stores; but few of the streets have very heavy teaming. Figures furnished by the department for 1907 show that there are about 28 miles of streets in this district, swept from one to three times per week. These figures probably cover what it is intended to do rather than what is actually done. A few of the more important streets are covered also by the push-cart patrol.

This district embraces about 276,000 square yards of paved street and about 228,000 square yards of macadam, but on these macadam streets the department cleans only the gutters. If we call the gutters 4½ feet wide the area of those actually cleaned is about 64,000 square yards. In general, the paved streets are cleaned three times per week, and the gutters on the macadam streets once per week. The machine sweeping is done at night, except in the winter, two two-horse sweeping machines being used. In dry weather a watering cart precedes the sweepers, but in wet weather a single horse sweeping machine takes the place of the sprinkling cart. No attempt is made to remove the sweepings until the next morning, when a force of men bunches the dirt in the gutters and the carts follow, taking it up, but this operation extends far into the day, often being not completed until late in the afternoon. In the meantime the dirt in the gutters is scattered by the travel and the wind.

The force employed consists of:

2 two-horse sweeping machines and drivers.
1 sprinkling cart or 1 one-horse sweeper and driver.
8 broom-men.
7 street carts, with drivers and helpers to take up the sweepings.

The horses employed all belong to the city, and are kept at the South stable.

While the actual width of the gutters does not in any case exceed 4 feet the sweeping machine covers a width of about 6 feet in passing along each gutter, although the broom is so adjusted as to sweep a path about 4½ feet wide.

It is intended to keep separate note of the miles swept on the paved and on the macadam streets, but this is not always

done, particularly where a strip of macadam road occurs in the midst of a paved district. The records are, therefore, not strictly accurate.

The details of the pay roll cost of machine sweeping in this district for the ten-week period are given in Table No. 47. Some of the figures in this table seem questionable, but they are

Table No. 47.

Cost of Street Sweeping (Machine), District 8, Uptown, for a Period of Ten Weeks, May 29 to August 6, 1908. Data from Actual Weekly Pay Rolls.

ITEMS.	Total Number of Days' Work.	COST OF MACHINE SWEEPING.		Cost of Collecting Sweepings.
		Paved Streets.	Gutters.	
Foreman	70	$92 70	$31 60	$144 40
Inspectors and sub-foremen	109	112 20	38 60	176 20
Sweeping machine drivers	111½	190 13	60 75	—
Watering cart drivers	48	79 88	28 11	—
Sweepers and bunchers	517	862 91	300 38	—
Shovelers and loaders	368½	—	—	829 12
Team drivers	368½	—	—	829 13
Dumpman	53½	—	—	120 38
Holiday pay	—	125 80	43 60	197 73
Total pay roll	—	$1,463 62	$503 04	$2,266 96
Add city horses at $1.70 per day	635	340 00	113 00	626 50
Total cost	—	$1,803 62	$616 04	$2,893 46

Total area cleaned once, square yards	6,882,800
Cost per thousand square yards, sweeping	$0 351
Cost per thousand square yards, collecting	424
Cost per thousand square yards, total	$0 775
Number of sweeping machine days	111½
Square yards covered per day, per machine	61,800
Number of loads of sweepings collected	1,739
Cost of collecting sweepings per load	$1 66
Number of cubic feet of sweepings collected	74,700
Cubic feet per thousand square yards	10.8

based on the department records and there seems to be no way of verifying them. Thus, it appears that the sweeping machines covered an average of 61,800 square yards per day of practically seven and one-half hours. The records show that 74,400 square yards of paved streets and only 22,300 square yards of gutters were swept per average machine day.

The former is very large and the latter is very small. These apparent discrepancies are not accounted for, and the average performance as compared with District 8, downtown, is so excessive as to excite suspicion. It is possible that the two kinds of work are not properly divided. There is no data obtainable outside the department records. The only explanation of the large performance of the machines that seem plausible is that all the streets reported as machine swept, in accordance with the schedule, were not actually gone over by the machines. The high cost for labor outside of machine sweeping suggests that some of the streets may have been regularly cleaned by hand sweeping rather than by machine sweeping, although there is no record of it.

In this district, while the machine sweeping is done during the summer at night, nothing is done until the following morning toward collecting the dirt into piles in the gutters and removing the collected dirt. Often parts of this is not done until the afternoon of the day following the night's machine sweeping, and in the meantime the dirt is more or less scattered by the travel over the street, and the higher cost of this part of the work over that in District 8, downtown, is doubtless, partly at least, due to the additional labor thus made necessary. It ought to be accepted as a standard rule of action that the bunching and collecting of the sweepings should follow the machine sweeping promptly. Partially at least, as a result of this practice, the street cleaning in this district is much less efficient and satisfactory than in District 8, downtown. Altogether, the observer is impressed with the fact that the work in this district is not nearly as well managed as that in District 8, downtown, and the much higher cost of the work as a whole seems to confirm this conclusion. The men work listlessly and without spirit. The difference in this respect between the force in this district and that in 8, downtown, is very noticeable.

A short study of the work in District 9, for the month of June, 1908, was made, with the result shown in Table No. 48. The force employed, as per the pay rolls, was as follows:

1 foreman.
2 inspectors.
1 one-horse water cart and driver.
2 one-horse sweeping machines and drivers.
6 to 7 broomers and bunchers.
3 drivers of city horses.
2 to 3 drivers' helpers.
1 dumpman.
5 to 6 city horses.

The actual daily pay roll charge was $45.83, of which $9.83, or over 21 per cent of the whole, was for foreman and inspectors alone. It seems wholly unnecessary that two inspectors should be attached to this small force. The foreman alone should have been able to handle the work without any inspectors.

Table No. 48 shows that the cost of cleaning per 1,000 square yards was 69.6 cents, which is very high, though slightly cheaper than shown on Table No. 45, and practically the same as for the year 1907, and the quantity of dirt collected was small, about 7½ cubic feet per thousand square yards.

Table No. 48.

Cost, etc., of Street Cleaning in District No. 9 in the Month of June, 1908.

ITEMS OF ACCOUNT.	COST, PAY ROLLS AND CITY HORSES.		
	Paved Streets.	Gutters.	Totals.
Foreman and inspectors	$122 19	$139 87	$262 06
Water carts and city horses	60 65	14 15	74 80
Single-horse sweeping machines and city horses	141 55	28 32	169 87
Brooming and bunching	104 64	252 00	356 64
Drivers and city horses (single teams)	101 10	210 40	311 50
Drivers' helpers	56 25	93 37	149 62
One hired team and driver	1 75	84 00	85 75
Dumps	27 56	27 57	55 13
Holiday allowance	26 66	44 44	71 10
Totals	$642 35	$894 12	$1,536 47
Square yards cleaned once	1,717,000.	493,100	2,210,000
Cost per 1,000 square yards	$0 374	$1 81	$0 696

Number of loads of dirt removed	392
Loads per 1,000 square yards of pavement cleaned	.177

All the evidence seems to prove that machine sweeping costs less in District 8, downtown, than in any other part of the city. During the ten weeks' period in 1908 which we examined the figures per thousand square yards cleaned were:

For machine sweeping	25.5 cents.
For collecting and disposing of dirt	20.0 cents.
Total	45.5 cents.

But to arrive at the entire cost of this work to the city certain other items, usually omitted from such statistics, must be taken into consideration.

The equipment required for the work in District 8, downtown, may be estimated as follows. (The actual inventory we have includes other districts.) The articles are not priced as new.

9 two-horse sweeping machines, at $200	$1,800 00
2 one-horse watering carts, at $200	400 00
18 sets single harness, at $40	720 00
13 carts for collecting sweepings, at $125	1,625 00
Miscellaneous small tools, say	155 00
Total	$4,700 00

Interest on this amount may be reckoned at 4 per cent, and depreciation, exclusive of ordinary repairs, at 10 per cent, or 14 per cent in all.

Interest and depreciation, 14 per cent on $4,700	$658 00
Ordinary repairs on this equipment would cost not less than 12½ per cent	587 50
The eight sweepers require, in addition, about twelve broom fillings per year, equal to ninety-six fillings, at $8.00	768 00
Total for year	$2,013 50
This would be proportionately, for ten weeks	$387 00
And for the 22,256 M. square yards cleaned would be, per thousand square yards	1.74 cents
Which added to the current cost of 45.5 cents above makes the total cost per thousand square yards	47.2 cents

This is exclusive of any payment for dumping privileges.

The above cost is not higher than in many other large cities where the streets are cleaned by the municipality direct, and is lower than in a number of such cities.

If the work could be done with equal economy throughout the whole city the showing would not be open to severe criticism. But reference to Table No. 44 shows that the cost in one district was $1.26, and that the average cost in the whole city was 67½ cents per 1,000 square yards cleaned. This average cost is much too high and could undoubtedly be greatly reduced. In my opinion the average cost over the whole city should not exceed 45 cents per 1,000 square yards cleaned once, and I believe that with proper organization, careful administration and strict economy this result might be obtained.

The experience of cities where machine cleaning is done by contract is interesting in this connection.

In Washington, D. C., all machine sweeping and the collection and disposal of the sweepings has been done by contract for many years. In 1906 a contract was entered into for a period of five years, under which the contractor does all the machine sweeping in the city and takes up and hauls away the sweepings, providing his own dumps, at the price of 22¾ cents per 1,000 square yards swept once. The city exercises rigid control and careful inspection of the work, and I can testify from personal observation that it is well done. The estimated area to be swept once, upon which the contract was based, was 300,000,000 square yards per year. Previous to this contract the city paid but 16 13/16 cents per 1,000 square yards for the same service.

In the city of Buffalo, N. Y., both machine sweeping and hand sweeping are done by contract. The contract for machine sweeping covers a period of five years and the price for sweeping, including the taking up and disposal of the sweepings, is 25 cents per great square (10,000 square feet), equal to 22½ cents per 1,000 square yards.

In St. Louis, Mo., machine sweeping is also done by contract, the prices paid per great square being 29 cents for granite pavement and 26 cents for asphalt and brick pavement. These prices are equivalent respectively to 26.1 cents and 23.4 cents per 1,000 square yards. In all these cases the contractor supplies at his own expense all the equipment required for the work.

Other cities might be named, but it is sufficient to say that as a rule the contract price for machine sweeping and caring for the sweepings very seldom exceeds 25 cents per 1,000 square yards swept once.

In view of the excessive cost of this work in Boston I would very strongly recommend that the work should in the future be done by contract.

There is no reason to doubt that if proposals were asked for, under strict specifications, to do all the machine sweeping in the city for a period of five years, a price under 30 cents per 1,000 square yards swept once would be secured from responsible contractors. Assuming that the contract price would be 30 cents, something must be added for superintendence and inspection in order that the cost may be fairly compared with the present cost. Under this system district foremen would not be necessary, but there should be a competent assistant superintendent having general charge of the work. A corps of competent inspectors would also be necessary to see that the work was done in accordance with the contract and specifications.

We have seen (Table No. 41) that the total area swept, including gutters, in 1907, was 330,300,000 square yards. At 30 cents per 1,000 square yards

The contractor would be paid	$99,090
Add salary of assistant superintendent	2,000
Add salaries of 20 inspectors at $900	18,000
Total cost	$119,090
Total cost per 1,000 square yards	36.1 cents.

At the average cost of the city work in 1907, 67½ cents per 1,000 square yards,

The total cost for the same service would be	$222,852
And if we call the cost by contract, in round numbers	120,000
The saving to the city would be	$102,852

I think it perfectly safe to say that under such a contract system of machine sweeping the city would save $100,000 per year as compared with the cost of the same direct municipal work in 1907.

Even with the most careful reorganization and the most economical management possible under direct municipal work, I believe that the cost would be greater than under the contract method and that the latter will be found the cheapest and most satisfactory.

If the contract plan should be adopted the first contract should require the contractor to take over the city's machine sweeping equipment at an appraised value. The contract should stipulate that the sweepings collected by the contractor in his work should belong to him, and be removed from the street and disposed of at his expense, under suitable regulations and restrictions.

The contract and specifications should be very carefully drawn, using as a model those of Washington and Buffalo, which have been the result of long experience.

Under contract machine sweeping it would be still more desirable to discontinue hand and machine sweeping on the same streets, and to reorganize the push-cart patrol force, shortening the routes of the patrolmen so that they should keep their areas satisfactorily clean without the aid of machine sweeping.

GUTTER CLEANING ON MACADAM STREETS.

The present practice of using full sized two-horse sweeping machines for cleaning gutters is unnecessarily expensive. If machines are used at all for this purpose, special one-horse machines with brooms sweeping a path 4 feet wide would be equally efficient and more economical. It is probable, however, that this work of gutter cleaning could be done still more economically by hand sweeping.

PATROLLING BY DISTRICTS.

This account covers the cost of collecting and disposing of the paper and other wastes deposited by the public in the barrels distributed over the central part of the city for that purpose.

The total cost of the service, the number of loads collected and the cost per load for each of the eight years is as follows:

YEAR.	Total Cost.	Number of Loads.	Cost per Load.
1900	$6,067	3,177	$1 95
1901	9,215	5,353	1 72
1902	4,673	2,313	2 02
1903	8,630	3,600	2 40
1904	7,978	4,856	1 64
1905	8,277	2,993	2 76
1906	6,982	2,497	2 80
1907	9,104	4,734	1 92

This shows a variation of 70 per cent in the cost of this service per load of waste collected during the different years of the period.

The cost of collecting and disposing of this material in 1907 was $1.92 per load. Considering the character of the work the cost is probably not unreasonable. But it is difficult to understand why it should have cost $2.80 per load during the preceding year.

COST OF KEEPING DEPARTMENT HORSES.

When a city department owns and uses the horses employed the cost of keeping these horses is often an important element in the cost of the work, which does not appear in the accounts.

The annual reports of the Street Cleaning Department of Boston for the years 1900 to 1907, inclusive, gives the cost of "Yards and Stables" as shown in the first two columns of Table No. 49. The number of horses kept by the department as obtained from the records is shown by column 3, and the total cost divided by the number of horses kept is shown by column 4.

It appears from this table that the cost of stables and yards per horse maintained has increased about 60 per cent in the eight years.

This deduction may, however, not be warranted, because the yards are used to some extent for other purposes, and some of the expenses are not a proper charge against maintaining the horses. At the same time, these other charges

have probably borne about the same relation to the cost of keeping the horses that they do now, and it is probably conservative to say that the cost of keeping the horses of the department has increased over 50 per cent in the past eight years.

Table No. 49.

YEAR.	Total Cost Charged.	Average Number of Horses Kept.	Average Cost per Horse per Year.
1900	$40,751	101	$403
1901	50,470	103	480
1902	68,302	106	644
1903	75,282	116	649
1904	77,775	119	653
1905	72,826	129	564
1906	77,548	125	620
1907	82,065	127	646

Upon making an attempt to determine accurately the cost of keeping the department's horses during any given year at all the department stables it was found that the accounts were so unsatisfactory, and the complications due to the keeping of the horses of two or more departments at the same stable were so great, that a large amount of work would be necessary and the results reached might not be reliable.

It was, therefore, decided to make examination of three separate stables only, which it was believed were typical of the others and would give correct average results for the whole.

The three stables selected were the South stable, the East stable and the Hancock street stable.

The results reached have been tabulated and are shown by Table No. 50.

The data all relate to the fiscal year 1907.

SOUTH STABLE.

This stable and yard is controlled by the Sanitary Department, but is occupied jointly by that department and the Street Cleaning Department. The latter department is

Table No. 50.

Cost of Maintaining City Horses, Fiscal Year 1907.

NAME OF STABLE. AVERAGE NUMBER OF HORSES KEPT.	SOUTH. 47.04				EAST. 32				HANCOCK STREET. 15.3			
ITEMS.	Total Cost for Year.	AVERAGE COST PER HORSE.			Total Cost for Year.	AVERAGE COST PER HORSE.			Total Cost for Year.	AVERAGE COST PER HORSE.		
		Per Year.	Per Day, 365 Days.	Per Day, 281 Days.		Per Year.	Per Day, 365 Days.	Per Day, 281 Days.		Per Year.	Per Day, 365 Days.	Per Day, 281 Days.
Superintendence	$1,404	$29 85	$0 082	$0 106	$1,200	$37 50	$0 103	$0 133	*$240	$15 68	$0 043	$0 056
Labor, including holidays	7,059	150 07	411	534	4,787	149 59	410	532	2,375	155 25	425	552
Hay and grain	7,437	158 09	433	562	6,313	197 28	540	702	3,180	207 82	569	739
Fuel, light, etc	311	6 61	018	024	350	10 94	030	039	213	13 88	038	049
Shoeing	1,720	36 56	100	130	1,410	44 06	121	157	628	41 05	112	146
Stable repairs	63	1 34	004	005	62	1 94	005	007	135	8 83	024	031
Veterinary service, medicine	594	12 62	035	045	389	12 15	033	043	184	12 00	033	043
Miscellaneous	131	2 79	008	010	111	3 47	009	012	70	4 58	012	016
Totals	$18,719	$397 93	$1 091	$1 416	$14,622	$456 93	$1 251	$1 625	$7,025	$459 09	$1 256	$1 632

* The district superintendent, Paving Division, superintends this stable. Ten per cent of his salary is here charged to the stable; also 10 per cent of salary of district clerk.

charged for a part of the repairs, proportional to the number of horses kept there by each department, and is also charged for rental, light and heat 2 cents per horse per day. Street Cleaning Districts No. 8, uptown; No. 9, downtown, and the patrol district (No. 11) stable their horses there.

The labor force kept by the Street Cleaning Department at the stable September 1, 1908, consisted of one foreman, one clerk, eleven laborers, six stablemen, one caretaker, one harness repairer, one bicycle repairer and one watchman, but in the accounts that follow all this force is not charged to maintaining horses.

Table No. 51.

Horses Maintained at South Stable, Street Cleaning Department, Fiscal Year 1907.

DATE.	NUMBER OF HORSE DAYS.				Driving Horses, Days at Work.
	Days at Work.	Days in Stable.	Days in Hospital.	Total.	
February	920	326	—	1,246	140
March	1,033	359	1	1,393	155
April	1,049	271	—	1,320	150
May	1,099	240	—	1,339	134
June	992	257	—	1,249	120
July	1,051	220	—	1,271	124
August	1,087	210	—	1,297	124
September	993	267	—	1,260	120
October	1,093	209	—	1,302	124
November	902	358	—	1,260	120
December	807	499	—	1,306	124
January	964	370	1	1,335	161
Totals	11,990	3,586	2	15,578	1,596
Totals divided by 365	32.85	9.83	—	42.68	4.37

Per cent of days at work, 77, including driving horses.
Per cent of days in stable, 23, including driving horses.

Table 51 shows the extent to whieh the horses of the Street Cleaning Department at the South stable were utilized during the year. The average number kept at the stable was 47.04. These are divided into two classes, the work horses proper

and the driving horses. The average number of the former was 42.68 and of the latter 4.36. The work horses together performed 11,990 days' work during the year and were in the stable 3,586 days. In other words, they were at work 77 per cent and in the stable 23 per cent of the days. Deducting Sundays and legal holidays and half holidays, only 281 days remain for work, which is 77 per cent of the whole year. Considering that more or less time must have been lost by rain and other accidental causes it appears that the department utilized to the full extent the work horses at this stable. The driving horses are each credited with working every day of the year. There is no way of learning whether this was actually the case or not, but there would seem to be no occasion to drive these horses every day in the public service. The record shows that only two days were lost by sickness among these horses for the whole year, which indicates that they were well cared for.

Table No. 50 gives the total and detailed cost of keeping the horses at this stable for the year for the items named. The labor charge includes only the men directly chargeable to the care of the horses.

The accuracy of the figures in this table cannot be relied upon, though they are probably substantially correct. In the item of feed, for instance, no inventory of the supplies was taken either at the beginning or the end of the year and the quantities purchased during the year may not correctly represent the quantity consumed.

Veterinary care, including medicines for the horses, is furnished by contract at $1 per month per horse. In addition to this another veterinarian has general supervision over all the horses of the department at a cost of $0.142 per horse per month.

EAST BOSTON STABLE.

The East Boston stable is jointly occupied by the Paving, Sewer, Street Cleaning and Sanitary Departments. The Paving Division has charge of the stable and buys all supplies, charging the other departments in proportion to the number of horses kept by each. The figures following, relating

to this stable, embrace all the horses kept there. The division of the cost between the departments does not seem to be equitable, but this does not affect our consideration of the results as a whole. The cost of keeping horses at this stable is shown in Table No. 50. Regarding the charges for hay and grain the remarks made with reference to the South stable apply here. No inventories of these supplies on hand at the beginning or the end of the year were taken, and only the quantities purchased during the year are available. The accounts are here further complicated by the fact that the stable is used jointly by the Street Cleaning, Paving, Water, Sewer and Sanitary Departments, each of which keeps separate accounts. It appears that the average quantities of hay, grain and straw purchased during the year per horse per day were as follows:

Hay	22.6 pounds.
Grain	14.4 pounds.
Straw	0.82 pounds.

The charge for blacksmithing at this stable, $44.06 per horse per year, is exorbitant.

HANCOCK STREET STABLE.

This stable is used by the Paving Division only. The property is owned by the city, and its assessed value is $27,000. The veterinary care of the horses is provided for by contract at $1 per month per horse.

The average number of horses kept here during the year was 15.3. The supplies purchased during the year indicate that the consumption was as follows:

Hay, per horse per day	24.3 pounds.
Grain, per horse per day	13.7 pounds.
Straw, per horse per day	1.23 pounds.

The cost of keeping horses at this stable is shown as it appears from the accounts in Table No. 50. The foreman of the Paving Division looks after the superintendence of the stable and only a small part of his salary is charged to the stable account.

AVERAGE COST AT THE THREE STABLES.

Taking the sum of the total cost per year at the three stables, as shown in Table No. 50, and dividing it by the average number of horses kept, it appears that the cost of maintenance for the ordinary items given in these tables averages $438 per horse per year.

While this is much in excess of the cost to private individuals and companies keeping large numbers of horses it does not compare unfavorably with the cost of maintaining the municipal horses in other large cities where I have had occasion to investigate the matter.

In Table No. 52 is brought together for ready comparison the itemized cost per working day of keeping horses at these three stables, and a column is added giving the true average of the figures at the three stables.

Table No. 52.

Comparison of Cost of Maintaining Horses at Three City Stables, Fiscal Year 1907.

ITEMS.	COST PER HORSE PER WORKING DAY ON BASIS OF 281 WORKING DAYS PER YEAR.			
	South Stable.	East Stable.	Hancock Street Stable.	True Average.
Average number of horses kept	47.04	32	15.3	—
Superintendence	$0 106	$0 133	$0 056	$0 107
Labor, including holidays	534	532	552	537
Hay and grain	562	702	739	639
Fuel, light, etc	024	039	049	033
Shoeing	130	157	146	142
Stable repairs	005	007	031	010
Veterinary service, medicine	045	043	043	044
Miscellaneous	010	012	016	012
Totals	$1 416	$1 625	$1 632	$1 524

It appears that the average cost of keeping the horses at the three stables, for the items enumerated in the table, is $1.52 per day.

But these items do not include other expenses that must be taken into account to arrive at the true cost per day's work of the city horses. The rental paid for the stables, or a reasonable interest on the amount invested where the city owns the stable, must be considered. The interest on the sum invested in the horses and a proper allowance for their depreciation must also be considered.

It is difficult to arrive at a fair allowance for rent or interest on the stable property. The rental and taxes paid for the East stable property is about $4,150 per year. It would probably be fair to charge two-thirds of this or, say, $2,700, to the horse account, which would amount to about $85 per horse per year. The Hancock street stable is assessed at a value of $27,000, and if interest, insurance and taxes amount to 7 per cent the annual charge to these accounts would be $1,890. If one-half of this be charged to the horse account it amounts to $62 per horse per year. These are only estimates, however, and may not be fair.

We may safely assume that the yearly rental, or interest, does not amount to less than $50 per horse. The average cost of the horses is about $350 and they are probably good for about seven years' service after their purchase. We may, therefore, figure the above general expenses per year as follows:

Rental	$50 00
Interest on cost of horse at 4 per cent	14 00
Depreciation, one-seventh of cost	50 00
Total	$114 00
Allowing 281 working days per year this amounts to, per day	$0 40
And if to this we add the ordinary current cost of maintenance, as arrived at above	1 52
We have as the total cost per day	$1 92

From which it appears that if the records may be relied upon and the assumptions with reference to the fixed charges are correct the city horses cost, in the year 1907, something over $1.90 for every day's work done by them.

The cost per horse per year appears to be:

For fixed or general charges	$114 00
For current maintenance	428 00
Total cost per year	$542 00

If the charge of $50 per year per horse for rental be excluded the cost per working day would be reduced to slightly over $1.70, and this figure has been used in computing the cost of work where city horses are employed.

Inquiry has been made among a considerable number of private concerns employing a large number of horses as to the cost of keeping them. The figures obtained differ materially with different concerns, but all of them are below $350 per horse per year, including rental of stables. While it is hardly to be expected that city departments can maintain their horses as economically as these private companies, it is evident that the cost found to prevail at the Boston stables is very excessive and might be greatly reduced. If the average cost of the items given in Table No. 50 could have been reduced from $428 to even $1 per day the total saving in the cost of keeping the 127 horses of the Street Cleaning Department in 1907 would have amounted to about $9,000.

HIRING HORSES.

The Street Cleaning Department, as well as other city departments, uses a large number of hired horses and teams. While there is some advantage in owning its own horses it is a question, upon the whole, whether it would not be better to hire all the horses needed by the department. The department previous to August, 1908, paid for horse and driver for carts $3.50 per day.

According to the figures above the cost of the same outfit, exclusive of the cart, is:

Cost of keeping one horse per working day	$1 70
Cost of driver per day	2 25
Total	$3 95

which is 45 cents per day more than for the hired horse and driver. The department also paid $6 per day for a double team and driver, while according to the figures above the cost for its own teams is:

2 horses at $1.70 per day	$3 40
1 driver at $2.25 per day	2 25
Total	$5 65

These figures do not take into account the cost of maintaining carts and wagons, of providing and repairing harness and other equipment, and of other miscellaneous expenses, all of which increase the cost of the city teams above the figures given.

Since August of this year the department has been hiring horses under contracts with large owners or contractors at prices materially lower than those previously paid and quoted above, resulting in a large saving to the city and making the contrast between the cost of city horses as shown above and hired horses much more striking.

The previous method of hiring individual horses and teams was unsystematic and, in at least a number of cases coming to our attention, irregular. Thus, horses were hired at $1 per day whether they worked or not, the city feeding, shoeing and otherwise caring for them. It was found that horses were hired upon these terms as follows:

Finn Brothers furnished one driving horse in District No. 7 from February 1, 1907, to the middle of January, 1908, 353 days being paid for during this time. James Galvin supplied two draft horses to District No. 7 from May, 1907, to February, 1908, a total of 518 days, at $1 per day. W. E. Boyle supplied one driving and two draft horses to District No. 1 from May, 1907, to July, 1908, a total of 774 days for the three. Boyle also supplied District No. 3 with one draft horse from May, 1907, to February, 1908, being paid for 255 days in that time. Other instances were found. At this rate of rental a good horse earns his full value in a single year's service without expense to the owner.

The plan recently adopted of hiring horses by wholesale rather than from single individual owners is to be strongly commended, and will undoubtedly result in the saving of quite a large sum of money. Still greater economy would result if the use of hired horses was generally substituted as far as possible for city owned horses.

I have already referred to the fact that a number of cities provide for all the machine sweeping and dirt collection by contract. If this custom were adopted in Boston the necessity for owning or hiring horses by the Street Cleaning Department would largely disappear.

But if the departments are to continue to keep large numbers of horses the whole stable system should be overhauled, a system of accounting should be adopted which will make it practicable to determine accurately the cost of keeping the horses in any one year and rigid economy in the stables should be enforced.

FINAL DISPOSAL OF STREET SWEEPINGS.

For the past eight years about two-thirds of the sweepings collected in Boston have been hauled to land dumps, and about one-third delivered to the scows of the Sanitary Department, by whom it has been towed out to sea and dumped. The same ratio prevailed in 1907.

The land dumps used have been owned by private parties and in a number of cases the city has paid the owner more or less compensation for the privilege of dumping on his property, besides keeping men on the dumps to assist in unloading the carts and to grade the dumped material. The usual price paid by the city for such dumping privileges is ten cents per load.

The Sanitary Department has charged the Street Cleaning Department for transporting the sweepings to sea from 23 cents to 27 cents per cart load, the present price being 25 cents per load.

No figures are available to show accurately the relative cost to the department of the two methods of disposal. The haul to the scow is shorter for a part of the territory cleaned, but the price paid for towing and dumping probably makes that method as expensive as hauling to land dumps in cases where nothing is paid for the privilege of dumping.

The cost of "Maintaining Dumps" in 1907, according to the reports, was about 4½ cents per load. For the year 1900 the cost, figured upon the same basis, was about 3.7 cents per load. The present cost seems unnecessarily high and should be looked into by the department.

I am convinced that these methods of disposing of the street sweepings are wholly wrong and result in great loss to the city. Private owners of low ground should pay the city a bonus for the material delivered, and to dump sweepings at sea is a needless waste of valuable material.

The city might use all its street sweepings for filling up low lands belonging to it, or purchased for the purpose. I am informed that the city owns a number of tracts suitable for the purpose, and that other convenient tracts could be bought at reasonable prices. These, if gradually filled in, will be so greatly increased in value as to make the operation very profitable to the city.

Shore areas now covered by shallow water, in localities where recovered land would be very valuable, could be bulkheaded and filled in at a very great profit to the city. Some of the islands belonging to the city in the harbor are surrounded by large areas of shallow water that could be similarly treated. The City of New York is now doing this on a large scale. Rikers Island, a very small island located in Long Island Sound, about ten miles above Battery Point, has been thus enlarged to 63½ acres and filled to a height of from 12 to 60 feet. A new bulkhead inclosing 147 acres in the shallow water has now been constructed and this new area will be filled to an average elevation of about 12 feet above the water in about six and one-half years. City penal institutions are being built on the part already filled, and the whole will in time become a very valuable addition to the assets of the city. The material used for these fillings includes ashes and miscellaneous rubbish as well as street sweepings.

The filling of salt meadows in the vicinity of Manhattan Beach, New York, with street sweepings, ashes and suitable rubbish from Brooklyn has been carried on extensively in the past ten years. A private corporation, holding a contract to dispose of these materials, installed a very complete organization and equipment for the work, collecting the refuse at a number of stations in the city and transporting it, largely by the street car lines, at night. Contracts for filling in were made by this corporation with the owners of the swamp land, who paid the corporation 10 cents per cubic yard for the material in place. Through the courtesy of parties immediately connected with the work I have been furnished with some particulars of the results.

One tract of about 60 acres of salt meadow, which was purchased at about $900 per acre, cost for filling to an eleva-

tion of 5½ feet above tide, less than $1,300 per acre. Within a very few years after the filling was completed the whole tract was subdivided into lots and was sold for prices which yielded over $5,000 per acre. The owners made about 100 per cent on their investment. Another similar but larger tract was filled to a level 7½ feet above tide. The owners bought the land just before the filling was done for about $900 per acre, and the filling cost about $1,600 per acre. Within one year after the filling was completed a part of the tract had been sold for over $5,000 per acre, and a sale of the balance at about the same price is now pending.

These may be exceptional cases, though they probably are not, but they show that the filling of low lands in the vicinity of a great city is a very profitable operation. The City of Boston should avail itself of opportunities to thus make the disposal of its street sweepings a source of profit rather than of expense.

There is a popular idea that, for sanitary reasons, street sweepings are not suitable for land filling, and that such dumps may become a nuisance if not a menace to the public health. There is good reason to believe that this fear is unfounded. The organic matter in the material is largely oxidized by exposure to the sun and air as it is gradually deposited in the dumps, so that putrefaction in the mass is largely avoided. Experience seems to confirm this conclusion. In the City of Washington, where great attention is given to sanitary matters, one of the oldest and largest dumps for street sweepings and street refuse, having a face 25 to 30 feet high, is in the immediate vicinity of respectable lodging house districts and not more than one-fourth mile from an aristocratic residence neighborhood.

This statement that deposits of street sweepings are not unsanitary is made upon the assumption that garbage, dead animals and such like actively putrescent matter are excluded from the material, as the law requires them to be. Where the city ashes and the street sweepings are collected and disposed of together, as they usually may be advantageously and economically, the organic matter in the street sweepings is still further diluted and the antiseptic action of the ashes still

further prevents putrescent action and renders the sweepings still less a menace to the public health, and still less likely to create any ground for complaint as a nuisance.

Another useful way of disposing of the street sweepings may be suggested and is worth serious consideration. In nearly every city complaint is made that the soil of the public parks is becoming impoverished, and the addition to the surface of a new virgin soil is urged as a public necessity.

Street sweepings from the smooth pavements is largely composed of animal excrement and it has a high value as a fertilizer. Some cities are able to dispose of their street sweepings to gardeners and farmers at a small profit, but in the case of the larger cities it cannot usually be thus utilized without transporting it to so great a distance as would make its cost excessive. Why should not this valuable material be utilized for the enrichment of the soil of the parks? A little extra care and expense in its collection to separate out objectionable materials, such as paper and other rubbish, would supply an admirable fertilizer for the impoverished soil of the city parks. The haul would usually be short, and the expense of properly spreading it over the surface would be small. Its use would be no more open to objection than would be the use of stable manure, or most of the commercial fertilizers, and it would serve an equally good purpose. The soil of the parks could thus be enriched at practically no expense whatever, since it would usually be less expensive to dispose of the street sweepings in this way than by the present methods. I recommend that this matter be given careful consideration by the park and street cleaning authorities, and that the popular prejudice against the use of street sweepings for this and other useful purposes shall be carefully investigated before it is condemned.

I had hoped to go into this matter of the disposal of street sweepings in much greater detail, but time and the necessary curtailment of expenses does not permit. The matter has not received the attention that it merits in our American cities.

SUMMARY.

Conclusions and Recommendations.

1. The expenses of the Street Cleaning Department increased nearly 48 per cent from 1900 to 1907, without, so far as can now be determined, any material increase in the quantity or quality of the work done.

2. At the present time the cost of administering the department and of cleaning the streets is much higher than it should be.

3. The cost of snow removal is excessive, being about 100 per cent higher than it should be.

I recommend that hereafter this work should be done by contract, under some such general plan as that now in use in the City of New York. It is probable that under such contracts the cost of snow removal,—assuming that the quantity removed be about the same in 1907–08,—the cost to the city would be reduced at least $50,000 per year.

4. While the cost of the push-cart patrol work has largely increased in recent years there is evidence that the quantity and quality of the work has steadily declined. At the present time this work is not properly organized and managed, and the patrolmen are so old that efficient service cannot be expected of them.

I recommend that this branch of the service shall be reorganized, that the men who are too old to render reasonably good service be provided for in some other way and replaced on the streets by competent, younger men; that the routes be readjusted and reduced in area so that the patrolmen can keep their areas clean without the aid of machine sweeping; that each patrolman shall be held strictly responsible for the condition of the route under his charge, and that the number of inspectors be materially decreased.

In my opinion the force of teams now employed to remove the patrol sweepings can be reduced, and the helpers now employed to aid the drivers should be dispensed with.

5. The machine sweeping should be done by contract. In my opinion the work could thus be done as well as it is at present, and about $100,000 per year could thus be saved to the city.

6. The cost of maintaining the city horses is excessive and could be materially reduced. The adoption of the contract system for machine sweeping would make it unnecessary for the city to keep so many horses and would greatly reduce the present loss to the city on this account.

7. The present methods of disposing of street sweepings are costly and wasteful. These sweepings should be utilized to fill low or submerged ground at a profit to the city which would probably eventually reimburse the city for the whole or a large part of the cost of disposal.

Respectfully submitted,

S. WHINERY,
Consulting Engineer.

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